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Cloud Computing for Schools

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M.Sc. in Computing (Information Technology)

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I certify that this dissertation which I now submit for examination for the award of MSc in Computing, is entirely my own work and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the test of my work.

This dissertation was prepared according to the regulations for postgraduate study of the Dublin Institute of Technology and has not been submitted in whole or part for an award in any other Institute or University.

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Abstract

This project evaluates previous Information and Communication Technology policy and practice relating to primary schools in Ireland with a view to suggesting a better way forward in light of advances in ICT, such as the availability of fast broadband services, including fibre broadband, browser-based applications and the advent of cloud computing. Cloud computing refers to the Internet as a source of both software programs and also data retention, in effect the Internet provides the software and data services via browsers to users who may remain entirely unaware of the technology at work, uncluttered by hardware or software licensing issues or problems and free to concentrate on activity and usage.

More specifically, this study questions the wisdom of large spending on soon-to-be-obsolete hardware and software packages in light of the fact that Internet browsers now offer access to both software applications and data storage without requiring users to have hard disks of their own for either the applications or the data. Cloud computing offers a better solution to computing in schools since it renders obsolete local hardware and software and their associated faults, repairs and licences and frees teaching staff from trying to muster technical support and allows the focus to centre on computing as an activity free from local constraints.

Furthermore, cloud computing allows for anti-virus, firewall, software services and updates at a single central point, instead of at a host of individual machines and schools. Cloud computing also allows trainers who are not physically present to teach classes via collaborative sharing online using screens, interactive whiteboards and Web video conferencing, such as many medical practitioners do routinely. This latter facility releases individual teachers from the burden of singularly providing all computing instruction.

This project shows that ICT infrastructure, primarily fast broadband, is a necessary prerequisite for all modern computing services and experiences on the Internet, and most particularly for cloud computing. Fibre broadband should be extended to every school in the Republic.

Keywords: Broadband for Schools, Computers for Schools, Department of Education and Science, DES, HEAnet, Higher Education Authority Network, ICT, Information and Communication Technology, Information Technology, Internet for Schools, Irish National Teachers Organisation, INTO, National Centre for Technology in Education, NCTE, National Education and Research Network, NERM.

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In particular I would like to thank the many primary school teachers whose complaints, difficulties and desires over the years inspired this study and who preferred not to be named.

Lastly, I thank the Social Care Agency of the Dublin Archdiocese, Crosscare, for its support of my studies.

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Glossary of Terms Used

Always-on - Telecoms service (particularly Internet access) which is always available, not requiring dial-up.

Asymmetric - A connection with the different bandwidth in both directions, usually slower for uploads and faster for downloads.

Backbone - On the Internet or other wide area network, a backbone is a set of paths that local or regional networks connect to for long-distance connections.

Backhaul - routing telecoms traffic indirectly to the intended destination for the purpose of taking advantage of tariffs or prices that are lower than those afforded by direct routing.

Bandwidth - The width of a communications channel, typically measured in Kbps (kilobits per second in digital systems). This measure gives an indication of how fast data flows on a given transmission path.

Bit-stream – a wholesale product whereby the incumbent installs a high-speed access link to the customer premises and then makes this access link available to third parties to provide high-speed services to customers.

Broadband - A high-speed connection which allows communications at speeds higher than can be achieved through basic rate ISDN (144kbit/s).

Cloud Computing – Internet-based computing via a Web browser, where the applications and data run on unseen, far-off servers ('in the cloud').

Digital - The use of a binary code (ones and zeros) to represent information.

Download/Upload speeds - are related terms used to describe the speed of transfer of electronic data between two computers or similar devices.

DSL (Digital Subscriber Line) – A family of similar technologies which allow ordinary telephone lines to be used for high-speed broadband communications. The family includes ADSL, HDSL, VDSL, etc.

Fibre/fibre-optic - Strands of very pure glass that can carry far more information than copper wires over far greater distances.

FWA (Fixed Wireless Access) - is the use of a wireless communications link as the "last mile" connection for delivering telephony services to telecoms customers.

Incumbent - The monopoly telecoms operator that existed in most countries prior to telecoms liberalisation. The incumbent is usually policed by a telecoms regulator to ensure that competing operators get fair access to its network.

Interconnection - The point at which one network hands over traffic to another network. The price and terms and conditions that apply to the handover are also referred to as interconnection.

Internet – The World Wide Web.

Leased lines - A leased line is a telephone line that has been leased for private use. Typically, large companies rent leased lines from the telephone message carriers (such as Eircom) to interconnect different geographic locations in their company.

Local exchange - The telephone company exchange where subscriber lines are terminated.

Local loop - The copper wires an incumbent has between its exchanges and its customers.

LLU - Local Loop Unbundling – Mechanism whereby service providers use the incumbent network to install their own broadband equipment for providing services.

Mbps (Megabits per second) – A measure of how many bits can travel between two points in a second in millions of bits.

Next Generation Networks (NGN) - a packet-based network which can provide a range of services independent of the network infrastructure, and can interconnect with multiple different types of networks offering greater flexibility and efficiency for operators and end-users alike.

Regulation - The process by which a government agency ensures that a complicated market like telecoms behaves as if it were a competitive market while one player, the incumbent, has an extremely powerful position in that market.

Symmetric - A connection with the same bandwidth in both directions.

Virtualization – More efficient method of running servers, aggregating numbers of real servers to a single server running 'virtual images' of the real servers.

VOIP (Voice Over Internet Protocol) – the routing of voice conversations over the Internet or any other IP-based network.

Wi-Fi - A trademark of the Wi-Fi Alliance for sets of product compatibility standards for wireless local area networks, intended to allow mobile devices, to connect to local area networks and is often used for Internet access and wireless phones.

Wi-Max (Worldwide Interoperability for Microwave Access) - a certification mark for products capable of forming wireless connections between them to permit the carrying of Internet data.

Wireless access - Access via a system that operates locally without wires.

1 Introduction

According to the National Centre for Technology in Education 2005 Census on ICT Infrastructure in Schools (Sheil & O'Flaherty, 2006) there were over 3,200 primary schools in the Irish Republic spread variously across overcrowded urban and sparsely populated rural sites. These schools housed in the region of 90,000+ individual computers of different ages and with a variety of operating systems and myriad different software programs all variously licensed and running in hardware subject to failure, repair or obsolescence.

At the 3rd International Workshop on Cloud Computing in Ontario, Canada, in 2009, Greg Olson argued: "*If a restaurant was growing its own food, slaughtering its own animals, generating its own power, collecting rainwater, and processing its own sewage, we would all think they were idiots for not using ready-made services*" (Litoiu & Iszlai, 2009). Each of the 3,200 independent primary schools was operating its own individual ICT system like Olson's imaginary restaurant in an era when the advent of centralised cloud computing makes possible vast savings on hardware, software, licensing and maintenance along with optimised and equalised services and resources for schools.

This paper seeks to apply the model of centralised cloud computing to the current practice in primary education of random computing in the absence of any model whatever.

1.1 Background

There are now in the region of four thousand primary schools across Ireland each independently operating its own ICT plan and associated assorted computers and software without any centralized controls or standardization. The totality of this plethora of individual sites offers an insurmountable obstacle to any coherent and futuristic ICT planning and to the provision of centralized and holistic technical support. The ICT free-for-all of the past decade has resulted in a digital divide where disparities in purchase and provision between wealthier and poorer schools mean that

pupils are experiencing an unequal ICT education. Many schools continue to operate obsolete computers and software. Added to all of this, very many schools' experience of the Internet suffers greatly owing to poor, patchy or wholly inadequate broadband provision. Irish teachers are among the least satisfied in Europe with regard to ICT in schools and the economic downturn promises little in the way of substantial investment to remedy this substandard situation.

1.2 Research Problem

The question arises whether there any advances in ICT in recent years which might offer an overarching solution to the problem of provision of ICT in Irish schools in a cost-saving and yet futuristic manner. By what means might the decentralized free-for-all across some 4,000 primary schools be brought into some kind of centralized control with the added benefit of holistic technical support and cost savings? Is there a solution to the digital divide whereby schools that are poorer or more remote from big cities might be enabled to give their students an equalised ICT education? Is there a way to use older or obsolete computers in cloud models such that they might match their more modern counterparts in usefulness and speed? Are there any such solutions in evidence in other countries which are also experiencing economic difficulties and which have very many schools in remote rural areas or very poor schools in inner city areas of deprivation? Is there a single solution to the patchy broadband delivery by a multiplicity of providers in Ireland which might effect an equal service nationally to schools and also save money over time? Are the new cloud technological advances impacting on the very model of learning as it has applied in schools heretofore?

1.3 Intellectual Challenge

The challenge involves researching nascent cloud definitions and deployment models in the literature and describing these in a clear and straightforward manner. It also requires the examination of cloud provision internationally whether commercially by large-scale multi-national companies or by governments in the light of intentions to render cost savings through forms of 'utility computing'. It is further necessary to uncover examples of cloud computing for schools already in place in cultures or

economies similar to those in Ireland and to discover why these examples have been deployed. It is important to grasp the impact of the latest technology trends on learning in and out of schools and how any new model of learning might be better served by a solution advanced in this study.

A vital area of research is the history of ICT and broadband provision in Ireland since the late 1990s when the National Centre for Technology in Education (NCTE) was founded to oversee the implementation of ICT in schools. It is equally essential to find and highlight the mistakes in planning and deployment by the NCTE since 1998 as evidenced in annual reports and published documents and in returns from the various censuses for computers in schools during the past decade and to closely read the various reports on computers for schools and broadband for schools which were requested by government and/or by the NCTE, and also those reports commissioned by the OECD and the European Commission.

A further imperative involves investigating the future policy on ICT as laid down in government national development plans for the 'smart economy', 'knowledge society' and for 'next generation broadband' delivery nationally. Alongside this it is essential to be aware of forms of futuristic cloud, virtualization and broadband provision internationally examining why these three are necessarily related.

Finally, it is essential to evaluate types of broadband and their advantages or disadvantages in order to render an opinion on the best type of broadband for schools and how it might be implemented across Ireland. This requires an investigation of any extant infrastructure in Ireland that might lend itself to use or re-use to provide fast broadband to schools across the country.

1.4 Research Objectives

Research objectives are:

- To define cloud computing and its various deployment models
- To uncover the advantages to schools and governments of a centralized, cloud model of ICT provision
- To examine examples of cloud computing already being deployed successfully in academia for the advantages outlined
- To clearly map the history of ICT in Irish schools both in terms of numbers of computers, networks established and technical support delivered
- Critically assess the quality of planning, tendering and implementation of ICT during the past decade
- Assess the provision of broadband with a view to establishing whether connecting all schools to the Internet via fibre optic cabling would be of benefit
- Highlight the mistakes or failures with a view to recommending solutions in the light of advances in technology
- Gauge the relation between government leadership with regard to ICT deployment nationally and positive or negative outcomes by comparison with another country's situation
- Look at opportunities to build on extant infrastructure to achieve 'next generation broadband' provision to all of Ireland's schools
- Judge whether a single model of cloud computing allied to fibre broadband would solve the problems outlined in Ireland's schools.

1.5 Research Methodology

Cloud computing is a new technology which has been exploited most successfully by such giants as Amazon and Google, Microsoft, Salesorce and Zoho, but has only recently begun to see governments seizing its rationalization and cost saving opportunities such as in Britain and Japan in examples discussed later. The academic application of its possibilities has occurred mostly in America, or else abroad in showcase models operated by largely the same American companies. While cloud

computing data centres and research models have been established by multinational companies in Ireland in association with universities and Irish companies, there is no model of cloud computing in academia anywhere in Ireland or in neighbouring UK as yet.

The research for this study of nascent cloud computing focused largely on literature review, taking into account published books, academic and associated governmental reports, alongside commercial studies commissioned by government bodies. Web sites of colleges, universities and giant computer companies involved in cloud computing furnished the desired examples of implementation of cloud computing in academia.

Primary research in this area was not facilitated by the main primary teaching union, the INTO, entering months of industrial action throughout the life of this paper. It is not within the capacity of this study to create or offer a cloud facility for primary research purposes. However, the secondary research on the history of ICT in Irish schools is detailed and extensive, and does not shy away from close analysis and judgment. Annual reports, government commissioned reports, census and commercial studies alongside European examinations of ICT in Irish schools were analysed and evaluated to give a comprehensive overview of what has happened to the provision of ICT and broadband in Ireland in the past decade. Comparison of American experience under President Obama's plans for technology in schools and his broadband initiatives for rural America and in deprived inner city communities greatly aids judgment of Irish initiatives.

The reader will find that this paper is fully informative of the history, practice and future possibilities for ICT in Irish schools in light of the advent of cloud computing and the feasibility of providing fibre connectivity to all Irish schools.

1.6 Scope and Limitations

This study defines models of cloud computing in commercial and academic settings, largely in an American context, though with some British and Japanese early governmental interest in the models, and seeks to apply them to problems deeply affecting Irish schools. It also endeavours to show how the regular provision in Ireland of inadequate broadband for schools requires enormous re-spending to create migration to better bandwidth and contrasts this expensive and unproductive provision with a model wherein a once-off fibre connection to all schools in Ireland would actually save money over time. The study is based on publications and literature on the nascent technology and on examples already implemented in American schools and colleges.

It is far beyond the scope of this paper to provide a cloud example in Ireland or to create a cloud model to put in front of teachers involved in industrial action. However, it is well within the scope of this study to show conclusively on the basis of evidence gathered internationally that the current unplanned and chaotic ICT provision across some 4,000 independent primary schools cannot continue and that only a centralised solution, based on a single cloud model, can equalise the ICT experience of all primary school pupils in Ireland in a cost-effective manner with technical support centralised at the cloud location and with the ability to re-use older computers already regarded as obsolete in schools.

1.7 Organisation of the Dissertation

Chapter 2 introduces the concepts of cloud computing and utility computing and describes the cloud service layers and deployment models. It then describes plans by a number of governments to implement the centralization and savings associated with cloud computing and working examples in various school districts and universities in the United States.

Chapter 3 records the historical development of ICT in Irish schools and the initiatives and bodies created to drive ICT implementation across Ireland. It examines the first blueprints for and surveys and censuses of computers in schools up to 2006, noting the early failings and issues that were to later bedevil ICT deployment in schools. It follows the slow extinction of technical support provision down the years as recorded in a number of NCTE annual reports.

Chapter 5 details the government and IBEC plan to provide 'high-speed broadband connectivity' to all schools by 2006 and implementation of a schools' network on the HEAnet network, and records a critical flaw in the plan. It then offers a forensic examination and decisively critical discussion of the crucial Norcontel evaluation report of the schools' broadband programme and of its methodology. It notes the fatal and downplayed bandwidth block and conflict of interest in the work.

Chapter 6 outlines the first major breach in the self-fulfilling Irish certainty of doing well by schools in ICT provision. The EC Empirica benchmarking study of ICT in European schools in late 2006 put Ireland at the very bottom in Europe of teacher satisfaction with ICT in schools and near the bottom in readiness to use ICT in the classroom.

Chapter 7 describes the Irish Government's seemingly swift response in 2007 to the EC criticism by appointing a strategy group and in planning to allocate €252 million over the next 6 years to ICT matters. It notes problematic issues in the composition of the strategy group and its inability to grasp the level of failure of the NCTE over the previous eight years to accomplish its tasks. It outlines some of the absurd recommendations of the non-technical strategy group.

Chapter 8 contrasts the plan of President Barak Obama's Secretary of Education, Arne Duncan, to transform American education to keep pace with technology-powered learning where fast broadband, i.e. fibre broadband, is a prerequisite for both new models of learning and also for the fruits of virtualization and cloud computing. The broadband for schools program is clearly shown to bring regeneration to entire communities surrounding the schools which get fibre broadband, but also enables the

schools to reap the proven benefits of virtualization and cloud computing to the extent that utility computing for poorer schools in now achievable.

Chapter 9, by contrast, tells of the technical and imaginative poverty of the Irish government's plans for the 'smart economy' and economic regeneration where broadband for schools and the 'National Broadband Scheme' provide only the most basic broadband connectivity, and no fibre at all. However, in the 'Knowledge Society Strategy' and in the Forfás report on Ireland's broadband performance, there is a clear demand for fibre broadband rollout in Ireland in order to facilitate economic regeneration.

Chapter 10 presents various maps of fibre already laid across Ireland, which, in association with the HEAnet backbone, offers an opportunity to connect all schools (and surrounding communities) in Ireland to fast fibre broadband once and for all to end the constant migration costs of the current regular upgrade requirements. This solution would allow the creation of Ireland's E-Cloud, or Education Cloud, as the single sole locus for hardware, software, maintenance and support and the delivery of the benefits of cloud computing to schools.

Chapter 11 concludes the study and summarizes the arguments in favour of cloud computing as against the current laissez-faire, ad hoc ICT provision across Ireland. It offers an evaluation of the contribution to the body of knowledge, the research undertaken and recommendations, and finally opportunities for future research.

2 Cloud Computing

2.1 Introduction

This chapter outlines the origins of cloud computing and utility computing and describes cloud service layers and deployment models. It details plans by a number of governments to exploit cloud computing for its vast savings and secure and simplified architectures. It shows working examples of cloud computing in academia in America.

2.2 Internet as Cloud

Toby Velte records that the Internet has for some years been represented in network diagrams as a cloud intended to represent "all that other stuff" (Velte et al., 2009) that makes the network work, purposely transparent to the browser viewer who needn't bother about how it works – the 'other stuff' is someone else's concern, so the diagram need not be detailed.

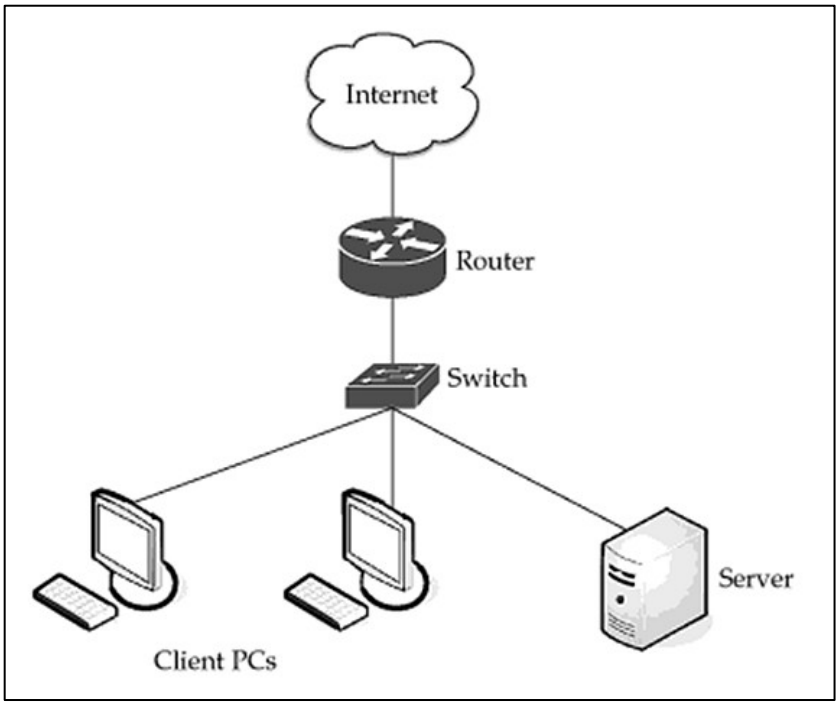


Figure 1 - Internet as Cloud (Velte et al, p.4)

It is the user's freedom from concern about the infrastructure that renders the services offered across the Internet – or cloud – so much like a utility that the user may regard them as accessible as water or electricity, to be switched on and off when desired.

The concept of computing as a utility had first been mentioned by MIT Professor John McCarthy in a speech for MIT's 1961 Centennial when he famously said: ""*computing may someday be organized as a public utility just as the telephone system is a public utility.... The computer utility could become the basis of a new and important industry*". In 1969, Leonard Kleinrock, a scientist of the Advanced Research Projects Agency Network (ARPANET) which created the foundation of the Internet, said: "*we will probably see the spread of 'computer utilities' which, like present electric and*

telephone utilities, will service individual homes and offices across the country" (Kleinrock, 2005).

Cloud computing is not just the Internet, but the combination of both the applications delivered as services over the Internet and the hardware and systems software in the data centres that provide those services. It is the combination of the data centre hardware and software that makes up the Cloud.

2.3 Cloud Service Layers

The U.S. *National Institute of Standards and Technology* Information Technology Laboratory definition of cloud computing describes three service layers: Software as a Service (SaaS), Platform as a Service (PaaS) and finally Infrastructure as a Service (IaaS) (Mell & Grance, 2009).

Web email services such as Hotmail and Gmail, Word Processor-like services such as Google Docs and Zoho, financial services such as Quicken Online and almost any online banking software, delivered across the Internet, are examples of **Software as a Service**. They may require a subscription or be entirely free of charge.

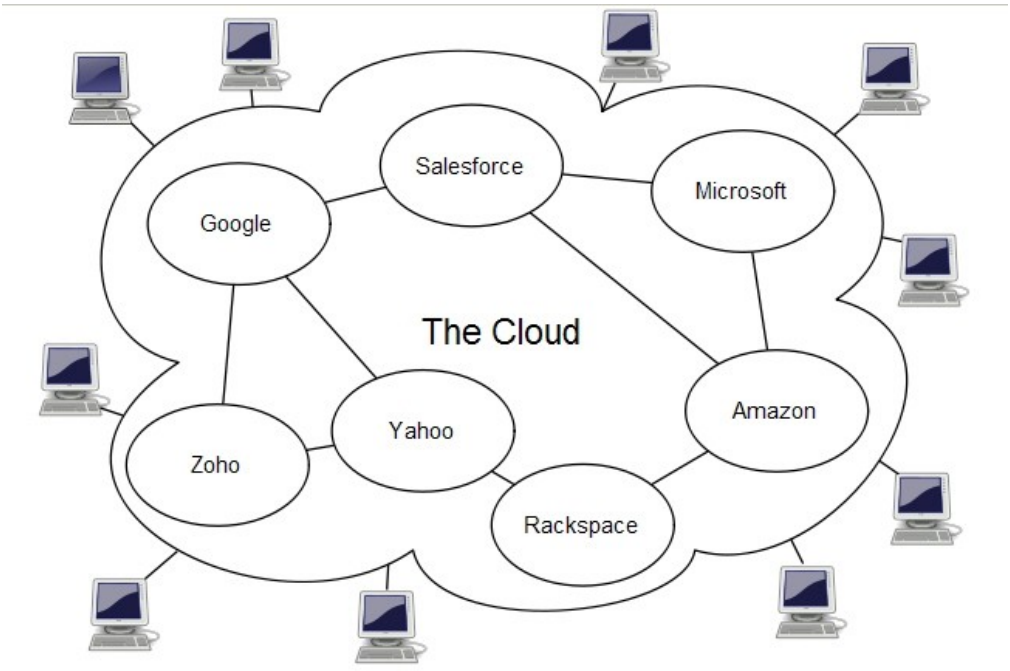


Figure 2 - Saas in the Cloud (www.samj.net).

The user interacts with these services entirely through a Web browser and the data is usually both generated and stored in the cloud, making it accessible through a range of devices, not only computers.

Platform as a Service involves the consumer deploying software applications onto the cloud infrastructure and running them there, however large or small they may be, thereby avoiding any CapEx (capital expenditure) on servers or infrastructure; the platform is usually scalable and elastic so that as usage peaks or dips, the platform automatically expands or contracts to meet the need. Programming platforms and tools (such as .NET, java or python) and APIs for building cloud-based applications and services are exposed to developers who can create applications for testing or for commercial purposes for a minute fraction of the cost of provisioning server infrastructure for themselves. Google's App Engine allows developers to write programs to run on Google's infrastructure or platform. Other examples include Amazon Simple Storage Service (S3), Azure Storage, and Force.com.

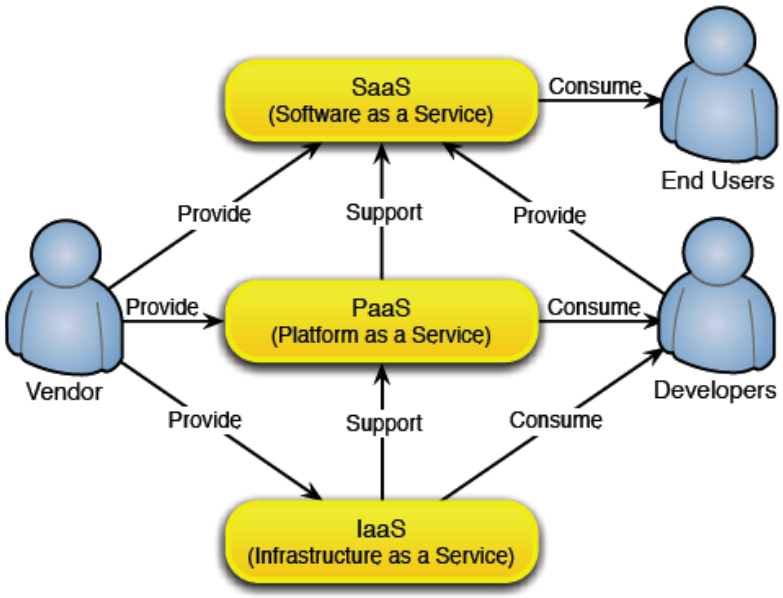


Figure 3 - Cloud Services to the Consumer (Briscoe & Marinos, 2009, p.2).

Infrastructure as a Service involves the user deploying not just software applications, but entire virtual machines or virtual server images operating any number or types of programs to run on the cloud infrastructure with the ability to stop, start, duplicate and mirror these any required number of times. The user may also be

able to provision processing power, disk storage, networks and firewalls. A company operating 1,000 servers along with all the costs of hardware and software, electricity and cooling, maintenance, labour and building space might more economically move these to virtual servers in the cloud for a fraction of the original expense. Examples of Infrastructure as a Service include Amazon Web Services and Amazon Elastic Cloud Compute (EC2), GoGrid and Flexiscale.

David Wyld argues that the power of cloud computing and its utility pricing is easily grasped in the case of the New York Times desire to convert to PDF roughly 11,000,000 scanned articles dating from 1851 to 1989. The NYT's IT Department estimated in 2008 that it would take over a month to convert the .tiff files to PDF but an IT staffer set up an account with Amazon and the 4TB (terabytes) of scanned .tiff files were first uploaded to Amazon's S3 storage, and then converted in Amazon's EC2 on 100 LINUX machines in less than 24 hours at a cost of less than $500. (Wyld, 2009).

2.4 Cloud Deployment Models

The U.S. National Institute of Standards describes four cloud deployment models:

- A ***Public Cloud*** infrastructure might be intended to serve the general public or a large industry group and may be owned by an organization actually selling cloud services. Various Amazon, Google or Microsoft offerings might fall into this category.
- A ***Community Cloud*** might be shared by a number of organizations and support a particular community with shared aims or concerns whether they relate to security, policy or mission. It may be managed by the organizations or a third party and may exist on or off site.
- A ***Hybrid Cloud*** may be composed of two or more clouds (private, community, or public) that remain separate entities but are interrelated by technology that enables data and application portability such as *cloud bursting* for load-balancing between clouds.

- A ***Private Cloud*** might be operated for a single organization and may be managed by the organization or a third party and may exist on or off site.

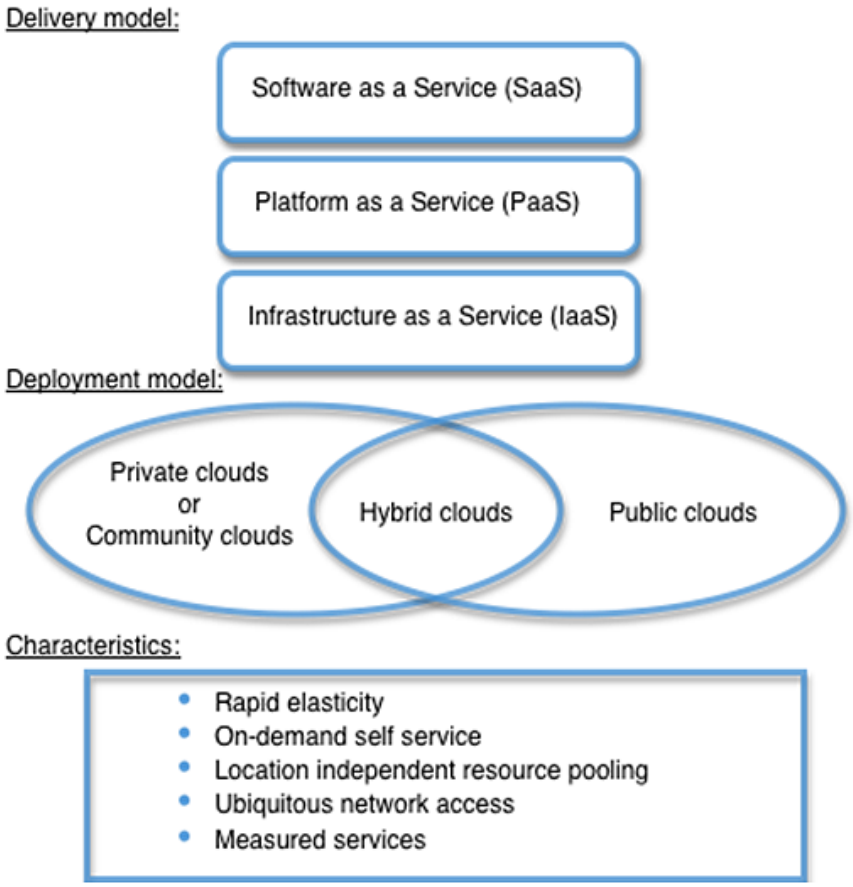


Figure 4 - Cloud Deployment Models & Services (Per Karlberg).

The British Government announced in January 2010 its intention to create a massive *Private Cloud* called the G-Cloud for the public sector in the UK with the intention of "*rationalising the government ICT estate, using cloud computing to increase capability and security, reduce costs and accelerate deployment speeds*". The infrastructure for the G-Cloud will be a reduced number of data centres, from some 500 to between 10 and 12, but these would be vastly increased in security, capacity and resilience such that "*cooling and power consumption will be reduced by up to 75% per year and infrastructure costs by up to £300 million per year*". By switching to open source software products and using a common desktop across its public service computers, the British Government hopes to utilise the Private Cloud to save in the region of a further £400 million per year. Total savings by use of the Private

Cloud model are claimed to reach £3.2 billion per year from a current annual bill of £16 billion (HM Government, 2010).

The Japanese Government announced in March 2009 its intention to create a new Government Cloud system, named *Kasumigaseki*, to reduce costs across the entire public sector and also to showcase Japanese facility with the newest technologies:

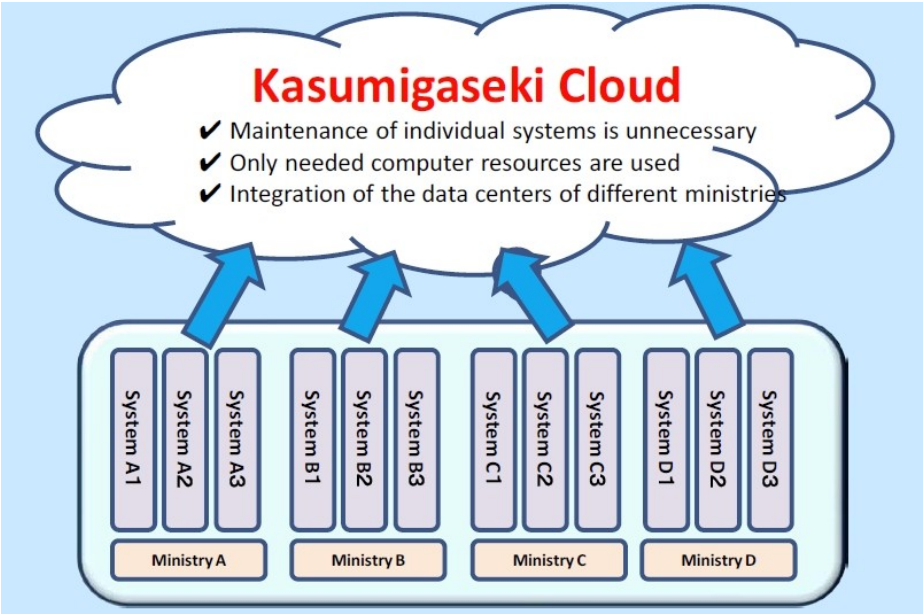


Figure 5 - Japanese Government Cloud (ICT Hatoyama Plan, 2009, p.5)

Siemens AG published a white paper on Community Clouds which incorporated elements of Hybrid and Public Clouds as well. The aim of a Community Cloud is to meet both the shared requirements of multiple parties in one or more businesses and also the various industry-specific requirements regarding functionality and security. In this hybrid model, a Private Cloud might take care of business critical data or functions, while a related Public Cloud might serve non-business critical functions and data. An example of this might be the provision of secure financial, legal or media data on the one hand and on the other services associated with provision of less secure staff email, blogs or Internet searches. In the area of knowledge management, a Community Cloud might successfully manage inter- and intra-organisational knowledge sharing of different security levels by management of hybrid cloud services and even bundled third-party services (Henneberger & Luhn, 2010).

In effect, deployment of cloud computing services according to the needs of customers results in the blurring of theoretical boundaries between deployment models.

Another deployment model for cloud computing has become popular since the NIST definition, and that is Desktop as a Service (DaaS) which has relevance for forms of academic computing (Erenben, 2009). This model replaces perhaps thousands of actual desktop computers with virtualised desktops delivered to either thick or thin clients from a cloud provider; the virtualised desktops run on virtual machines in a server cloud, offering the usual centralised control, cost-effective maintenance (since only software is actually being maintained) and usage (pay-per-view). The DaaS model is particularly relevant to the concept of cloud computing for schools, as will become evident in the following examples.

2.5 Cloud Computing in Academia

Pike County has 27 K-12 (kindergarten to secondary) schools in Kentucky, USA, with some 10,200 students requiring access to desktop computer services of different kinds. In 2009, and facing budgetary cuts and an inability to purchase 1,400 required new desktop computers, Pike County signed up to cloud computing services that involved delivery of up to 5,000 virtualised desktops to browsers on all of its desktops, including to those on the 1,400 redundant and elderly computers which were able to run the virtual desktops even though they had no internal hard disks of their own. The elderly computers could 'boot up' from a CD-ROM or USB memory stick and receive the virtual desktops from the cloud and operate as fast as any other thin client machines (Erenben, 2009).

Approximately 20% of its 6,000 desktops were running Windows 98, Windows 2000 or older and have no more than 64MB RAM, which isn't enough to run many of the newer, more memory intensive applications that the district wanted to supply. Some classrooms have six-year-old computers and applications, while others have a mix of old and new ones. This made it difficult to ensure equal education across the district. By making a deal with IBM and Desktone Inc., Pike County got the latest in Virtual

Desktop Infrastructure whereby the cloud delivers virtual desktops to any thin or less thin clients, entirely controllable by the local enterprise school system running on somebody else's cloud infrastructure (that of IBM and Desktone) as in the figure below:

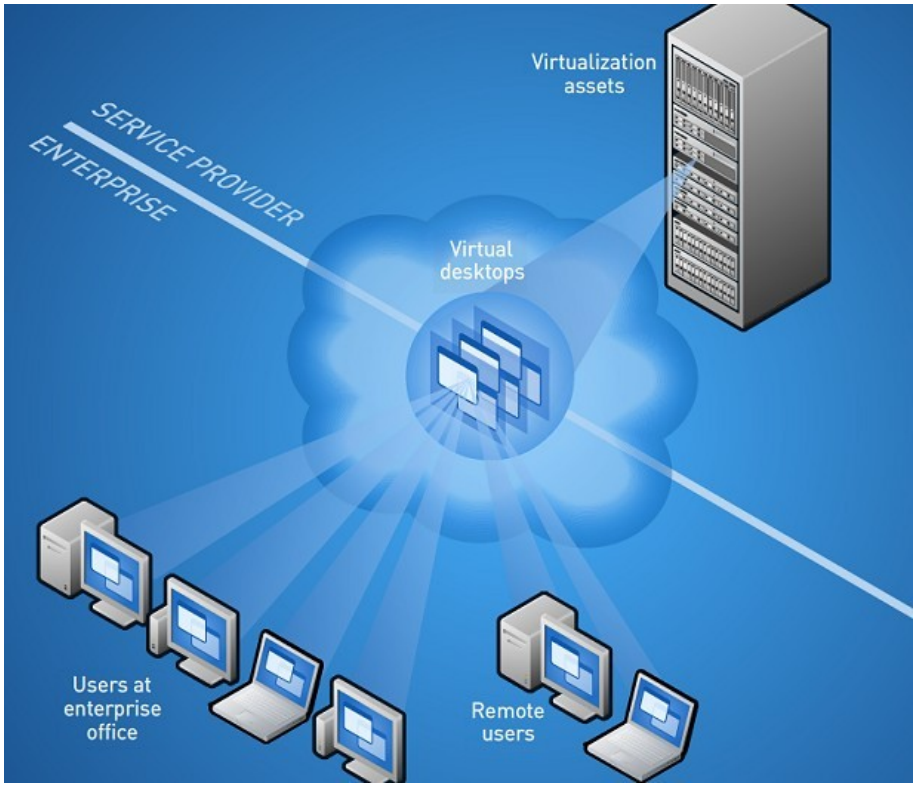


Figure 6 - Desktop as a Service from the Cloud (Desktone)

Each student now has a secure personal login and access to programs such as Microsoft Office, Internet browsing and various educational software offerings, along with personal data storage. Teachers also have logins and access to software for attendance, grade recording and lesson planning, as well as data storage.

> "**Universal access is the most phenomenal benefit of the Desktone-based solution.** In the past, some machines couldn't run key applications, or would be very slow accessing the internet, or couldn't stream media. Now, it's an equal playing field. There isn't any desktop that won't give users the access they need."
>
> — Maritta Horne, Chief Information Officer, Pike County School District

Figure 7 - DaaS Equalises Service

The cloud provider's DaaS merely requires the user to have a screen, an input device and any kind of communication device, whether laptop or desktop computer, mobile phone or any kind of PDA. Everything that formerly ran on the traditional desktop computer now runs on the server: the

processing power, the operating system, the software, and the user's files and data.

Advantages to Pike County include the resurrection of 1,400 redundant computers as new, working thin clients without the costs associated with the purchase of actual thin clients which were in the region of $1 million; vastly less maintenance and repair costs since the DaaS model does not require using the hard disks in any of their computers, along with the resultant electricity savings; no concerns about maintenance of server hardware or software or licences since these are now effectively outsourced. Above all, by deciding to subscribe to cloud computing services, Pike County has brought its computer-to-student ration down to 2:1 without spending millions of dollars.

Marist College in Poughkeepsie, New York State, operates cloud computing services on a pre-existing mainframe computer. By virtue of virtualization, the college runs 630 virtual servers on the single mainframe whose entire footprint is 2,000 square feet as against a gigantic data centre that might otherwise have to find space, electricity, cooling and support staff to maintain 630 actual servers (Erenben, 2009).

Marist College developed its own version of the open source Sakai education platform, entitled iLearn, not only using it internally but also distributing it to other schools and colleges who may also log in and use the cloud services.

The Marist mainframe cloud services 7,000 users within the college, but overall some 130,000 email accounts. New generation low-cost, low-power and hard disk-less thin clients are used on campus, but the SaaS/DaaS is so like a regular computer that users are entirely unaware that they are not using traditional PCs. Users may register, take a course, look up grades, pay bills, search the library catalogue, collaborate on line for team projects, post documents and presentations, chat and use Facebook. The centralised cloud service allows for network security to be controlled at a single point, along with anti-virus, spam, malware and other threats, and all data is stored securely on the cloud, not on any single user device.

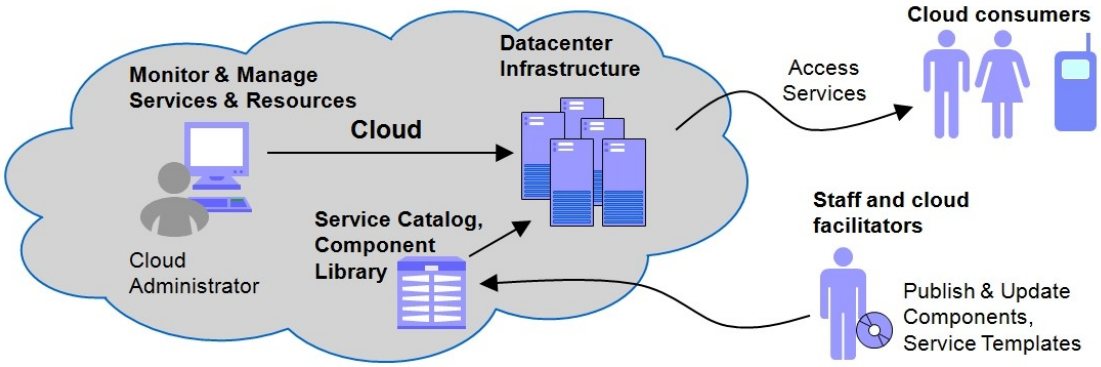


Figure 8 - Cloud Delivery from a Mainframe (Greggo)

Mainframe computers are not common and Marist was fortunate to have an older mainframe available for use with a massive and generously interested IBM research facility next door anxious to get students involved in mainframe research and programming.

The more usual data centre is made up of very many individual servers combined and North Carolina State University (NCSU) at Raleigh, North Carolina in the United States, runs an academic cloud, known locally as the Virtual Computing Laboratory (VCL), in a data centre composed of some 2,000 IBM blade servers along with a few HP and SUN servers (Erenben, 2009) spread across four data centres in Research Triangle Park, North Carolina.

Apart from the usual SaaS/DaaS desktop services to some 30,000 student and faculty users, professors can access a Web page and request any kind or combination of IT services, from booking an Apache Server instance along with a pair of database and application servers to even requesting a larger computational cluster or even a low-end supercomputer. In fact, users may even request a sub-cloud of their own, such as a high-end terabyte cloud or an application-oriented cloud.

NCSU offers pilot accounts to anyone interested in learning about VCL at http://vcl.ncsu.edu

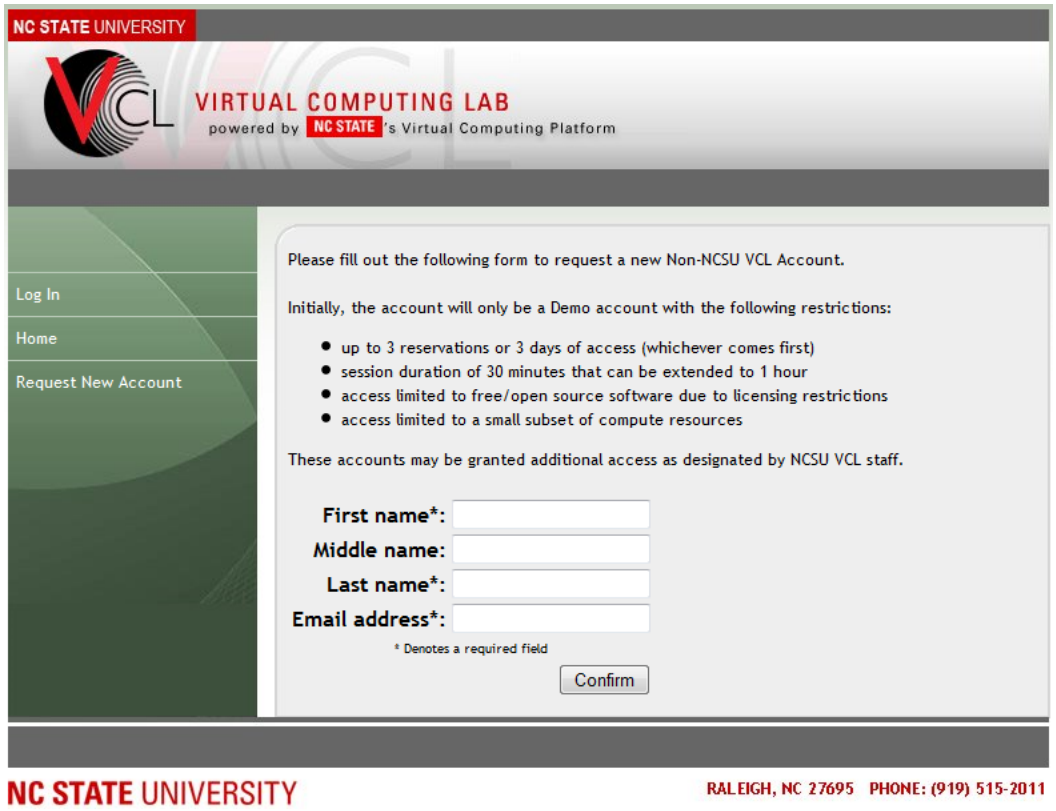


Figure 9 – NCSU Virtual Computing Lab Demo Access

2.6 Conclusion

This chapter introduced the concept of cloud computing and various models of cloud delivery. It showed how, even at this early stage in the development of cloud computing, both governments and educational establishments are already exploiting its advantages in an era of economic downturn. Clearly, cloud computing can be sold as a model that brings about potentially vast savings, along with centralized controls and security. It can also breathe life into older computers that were formerly destined for the scrapheap, which is a particular advantage for schools in Ireland.

3 History of Computing in Irish Schools

3.1 Introduction

This chapter describes the origins of computing in education in Ireland, and traces the early provision of ICT in schools by the Irish government and the bodies set up to implement ICT across the country. It analyses the first surveys, censuses and blueprint plans for the future and outlines early failings that later proved difficult to overcome, particularly in relation to technical support issues affecting over 3,000 primary schools.

3.2 Origins of Educational Computing

A disparate group of teachers in Ireland in the early 1970s, with support from the UK in the form of both ICL-CES (International Computers Limited Computer Education for Schools) and Loughborough University in England, formed the Computer Education Society of Ireland (CESI) in 1973 and began to study computers with a view to their use in education. After many years of lobbying Government and the Department of Education and Science, computer studies were added to the curriculum and eventually a national policy framework for ICT in Irish schools was promulgated by the Government (Oldham, 1985).

3.3 Schools IT 2000

On a visit to St. Aidan's CBC in Whitehall, Dublin, on November 28th 1997, the then Taoiseach, Bertie Ahern, and the Minister for Education and Science, Michéal Martin, with Mr Alfie Kane of Telecom Éireann, launched the national policy on information technology in education entitled *Schools IT 2000 – A Policy Framework for the New Millennium* (SIT2). SIT2 had two core objectives:

- That all pupils should have the opportunity to achieve computer literacy and to equip themselves for participation in the information society.
- That teachers should be supported to develop and renew their professional skills so as to enable them to utilise ICTs as part of the learning environment.

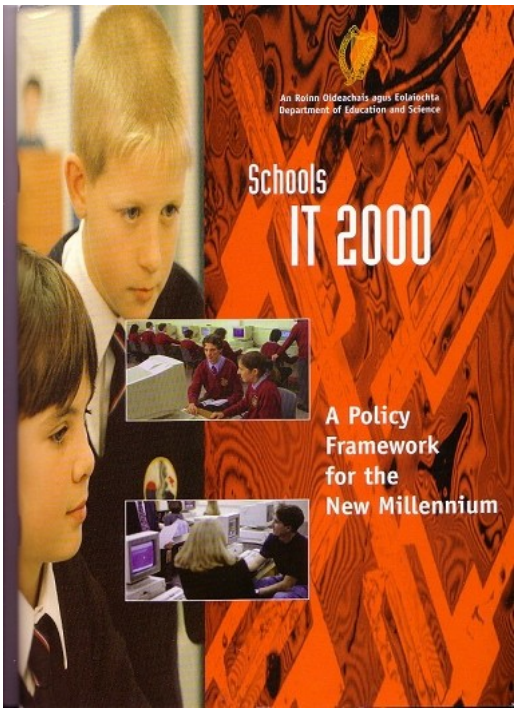


Figure 10 - Schools IT 2000

SIT2 proposed four key initiatives to implement ICT in Irish schools over three years:

- The **Technology Integration Initiative** (TII), intended to build technology infrastructure in schools.
- **The Teaching Skills Initiative** (TSI), aimed at the professional development of teachers in relation to ICT.
- www.ScoilNet.ie intended to be a national educational portal for teachers, pupils and parents.
- **Schools Integration Project** (SIP), to oversee pilot projects adopted by schools to uncover models of best practice in integration of ICT in schools.

To drive the SIT2 project and to advise Government, the Department of Education and Science in 1998 established the *National Centre for Technology in Education* (NCTE) based at Dublin City University campus and acquired funding of £40 million from Government plus £15 million from Telecom Éireann (Ireland's former state telecoms company, now Eircom). ICT was thus begun with a big bang.

In order to fulfil another commitment in SIT2, the *National Policy, Advisory and Development Committee* (NPADC) was established also in 1998 to create "at national

level a Policy Advisory and Development Committee, which includes representatives of the partners in education and the social partners." This body is mentioned because it commissioned a detailed review of the outcome of SIT2 which will be referenced later. NPADC was also based at DCU.

Anne Phelan of NCTE noted in a paper delivered at the International Special Education Congress 2000 at the University of Manchester that within two years the SIT2 project had achieved three of its primary aims, to get every school in Ireland connected to the Internet (and the Eircom support enabled this, even if only with modems and telephone lines), to have 60,000 multimedia computers in Ireland's then 4,100 schools and to have 20,000 teachers undergoing ICT training. The pupil to computer ratio in schools was estimated as being down to 18:1 from 37:1 before SIT2 (Phelan, 2000).

She further noted in a positive vein that TII was developed in such a way that schools were being "empowered to plan their own approach to technology integration and funded to purchase their own hardware and software" which, in hindsight, resulted in 4,100 imaginary Olson restaurants, each doing its own local thing in an uncoordinated, unplanned manner and collectively leaving a Jackson Pollock-style IT legacy to the future, an issue that escaped notice at the time.

3.4 Impact of Schools IT 2000

In 1999, the NPADC decided to carry out a national survey on the outcome of SIT2 on the primary and post-primary education system and commissioned PricewaterhouseCoopers to carry out the research. Between September 2000 and January 2001, questionnaires were sent to primary and post-primary school principals and teachers, Boards of Management and Education Centre directors and the findings were published in September 2001 in a report entitled *The Impact of Schools IT 2000* (ISIT2).

Among its largely congratulatory findings in respect of its sibling, the NCTE, and its paymasters, the Government and DES, the report noted even at this early stage that a proliferation of individual units of hardware were proving very problematic for schools to manage. It declared that "the DES must provide adequate, additional and separate funding to schools for the maintenance, repair and renewal of school ICT equipment on an annual basis and that Education Centres should be assisted in developing the expertise necessary for advising schools on how to resolve issues in relation to technical support." Furthermore, while 98% of schools had an Internet connection, only 30% used filtering to safeguard pupils browsing the Internet, 37% did not use filters, and the remaining 33% were unaware of the use of filtering in their schools. The independent Olson restaurants, as it were, were already running into problems.

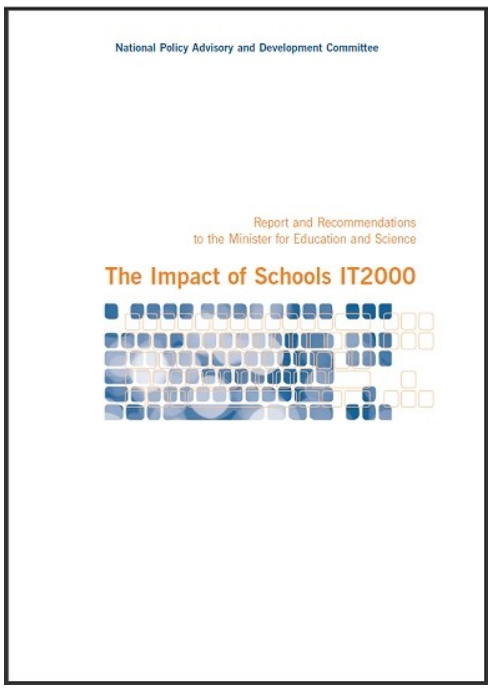


Figure 11 - Impact of Schools IT2000

3.5 Blueprint for the Future of ICT

The Government quickly followed up on its massive initial injection of ICT into Irish schools with the *Blueprint for the Future of ICT in Irish Education Three Year Strategic Action Plan 2001 – 2003*, published in December 2001, which committed to pumping another €107.92 million into ICT for schools, into infrastructure, training (ISIT2 had noted that 17% of principals and 33% of primary teachers were still not using ICT at all), development of www.scoilnet.ie and lowering of the computer/pupil ratio. Most significantly, for the purposes of this paper, the strategic action plan began "a major development of wiring-networking infrastructure in all schools and the introduction of broadband access to the Internet". But there were still no centralised requirements on schools in relation to how their local ICT was planned or developed.

3.6 NCTE 2005 Census

After a further four years, another survey was undertaken, entitled the *NCTE 2005 Census on ICT Infrastructure in Schools*, to reflect the situation pertaining in May and June of 2005. The Educational Research Centre at St Patrick's College, Drumcondra, Dublin, was asked to produce a statistical report based on the census returns from which the following information is extracted (Sheil & O'Flaherty, 2006).

While this census showed that the pupil/computer ratio was down modestly in primary schools from the 2002 ratio of 11.3 to the 2005 ratio of 9.1, it also recorded that 30% of computers in primary schools were more than 6 years old, with the corollary that 4 years after the release of Windows XP, many thousands of school computers were still running Windows 95, 98, 2000 and ME and legacy software was becoming embedded in classrooms.

In spite of the €163 million spent on ICT in the previous 7 years, in 2005 primary schools could report that 55% of their computers were not networked and 56% of them had no Internet access. 39% of primary schools did not have a network installed at all. In the case of smaller primary schools, almost 50% did not have a network installed. While 79% of primary schools stated that they had an ICT plan, over 50% of them admitted it had not been updated on an annual basis. 68% of primary schools reported that they had not facilitated any ICT professional development for staff in the two years preceding the 2005 census. 85% of primary schools indicated that accessing technical support and maintenance for the ageing hardware was either a 'very high' or 'high' priority.

The census reported that "areas that were prioritised to a lesser degree included accessing advice and guidelines on the purchase of hardware and software, standardising operating system software across the school, and providing online content to students and staff." In other words, not only were many schools continuing to operate in an entirely uncoordinated and independent manner, but even within particular schools ICT remained ad hoc and without a coherent plan for the future. Perhaps the schools were beginning to discover that their core business was teaching

and that endeavouring to manage ICT was becoming an expensive and time-consuming distraction.

It is no surprise then to read that almost 75% of primary schools indicated that they would like to be part of a centrally provided technical support service for schools, while 50% indicated an interest in being part a local cluster of schools having a contract with an IT company/contractor. In their comments, some school principals noted that staff did not have the expertise to deal with ICT contractors, and were not always sure that they were getting value for money. Principals of particularly rural primary schools reported difficulty in accessing call-out services due to the remoteness of the area in which their school was located. These comments might very well be interpreted as expressions of a desire for centralised purchasing, planning, maintenance and support, which are the very ingredients which seed clouds, so to speak.

3.7 ICT in Schools

While the NCTE 2005 Census was a snapshot of the ICT situation in schools in May and June of 2005, a much more comprehensive study was undertaken throughout the school year 2005/2006 by the Department of Education and Science Inspectorate's Research and Evaluation Unit and eventually published in 2008 entitled "*ICT in Schools*". The evaluation methods of interest to this paper comprised a national survey of 234 primary principals and 1,162 primary teachers, case-study school evaluations by inspectors of 32 primary schools and observations during classroom inspections in 77 primary schools.

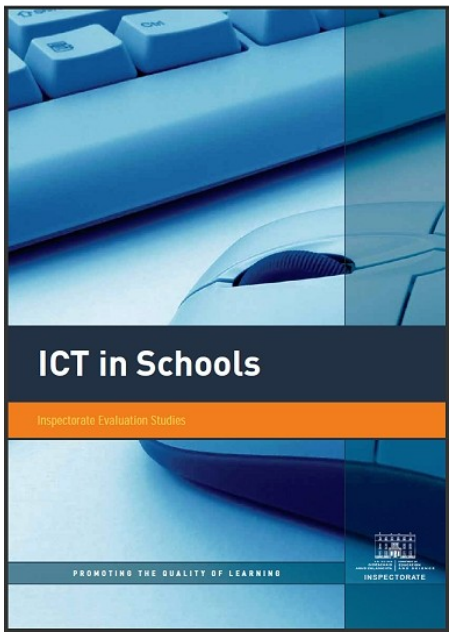


Figure 12 - ICT in Schools

Section 3.3 includes an unusual admission: “An examination of ICT funding issues in individual schools was not a priority of this evaluation: the priorities were more concerned with pedagogical issues. However, schools repeatedly raised the issue of funding during the evaluation, particularly in the case-study school evaluations” (DESa, 2008).

Under Ireland’s laissez-faire ICT provision, the fact that schools were free to enhance their ICT by raising extra funds from private sources began to create a disparity where some schools were able to raise a lot of money and others very little. This tended to exacerbate a ‘digital divide’ across the country where relatively wealthy schools were able to provide better for their students than relatively poor schools. Schools in cities were apt to provide better than smaller schools in isolated rural areas. This disparity directly contradicted one of the stated goals and objectives of Schools IT 2000 which was ‘to ensure that schools in disadvantaged areas, both urban and rural, receive early support so that they do not fall behind schools with access to greater resources (SIT2, p.18)’.

All of the 32 schools in the case study evaluations reported that the maintenance, upgrading and replacement of acquired ICT “was a cause of great strain” and was decimating their budgets (DESa, 2008).

However, the consequences for schools of the lack of centralised planning from the start were more apparent when it came to the free-for-all that occurred when schools went off and bought their own hardware and software and when many of them omitted to allow for the cost of maintenance and replacement of ICT or forgot that their location did not offer easy access to maintenance. Section 3.4 includes a direct quote from a principal: “All of the IT equipment in the school is old (pre-1999) and is constantly giving trouble. We have no technical expertise amongst the staff so maintenance is a problem. Teachers are discouraged and frustrated and the use of ICT becomes a negative experience for both student and teacher.” The same section refers repeatedly to the age of the computers, to computers not working, to software not being able to run in old computers and finally describes the evidence as “painting a picture of schools having computers that, for all practical purposes, are obsolete and should be disposed of (DESa, 2008)”.

While this snapshot of ICT in the school year 2005/2006 was less than optimistic about hardware, software and networking, it did offer a plea to the future, relevant to papers such as this one:

> 'It is clear also that the issue of maintenance in schools needs to be addressed *in a co-ordinated fashion at system level so that all schools can benefit from having a secure and reliable infrastructure* that will support the integration of ICT throughout the school. *A strategy is required* to ensure that a comprehensive ICT maintenance and support service is available to schools. *A range of models whereby this service could be delivered needs to be explored. These models could include clustering schools* for the purpose of taking out maintenance contracts with commercial IT companies, national or regional contracts for technical support for schools, or other options (DESa, 2008)'.

Indeed, a perfect invitation to future rainmakers to produce clouds.

3.8 Technology Integration Initiative Failure

In light of the troubling comments made in both the *NCTE 2005 Census on ICT Infrastructure in Schools* (published by Sheil and O'Flaherty in 2006) and the subsequent *ICT in Schools* referring to the 2005/2006 school year (not published until 2008), it is almost impossible to believe that the NCTE Annual Report for 2007 fails to mention any hardware or software problems at all, and the word 'obsolescence' is nowhere to be found in it. In fact, the NCTE Annual Report for 2007 represents everything as rosy in Olson's freelancing restaurants – menus are being suggested centrally, guidelines on food preparation are being advanced by a range of local Advisors, there are thousands of hits on the individual restaurant Web sites and quantitative statistics are only increasing!

Up to the July 25th 2010, the NCTE has not published an annual report since 2007.

It is clear that the single biggest failure of the NCTE since its inception lies in TII, *The Technology Integration Initiative*, intended to build technology infrastructure in schools. As Section 3.2 of the 2005 Census records, after over 7 years of operation, based in 21 full-time education centres across Ireland, each with its own full-time ICT Advisor and a full-time administrative assistant, a truly dreadful failure was reported.

52% of the 1,162 primary teachers who responded to the questionnaire stated they were unaware of the service in their local Education Centre. (At post-primary level, 63% were unaware of it.) Of those 48% of teachers who responded that they were aware of it, 54% had never used it and 37% were unaware that the service offered fully-funded ICT courses through local education centres. (At post-primary level, of the 37% of teachers who reported awareness of the service only 41% (15% of all respondents at this level) had ever used it.) The line that the survey "*found considerable disparity in the awareness levels of teachers in different parts of the country*" perhaps is really trying to avoid reporting that the percentages were even worse in particular rural areas, but rounded down less embarrassingly in averages. Finally, of the small number of teachers who availed of the fabled "school visit by the ICT Advisor" a staggering 42% of them felt that the service received was only "fair" or was downright "poor."

Is it any wonder then that the imaginary Olson restaurants, each doing its own isolated thing according to its lights, were brought about in Ireland by gross and wholly avoidable failure in Government ICT policy over at least these 7 years?

The report continues that the relatively low level of use among those teachers who ***were aware*** of the service may be ascribed to four factors:

- Insufficient knowledge on the part of teachers of the exact nature of the services offered.
- The relatively small number of ICT advisors, making it difficult for teachers to obtain access to the service.
- The distance of some teachers or schools from their nearest education centre.
- Lack of time on the part of teachers to engage with the service.

But the core flaw in the TII is not highlighted anywhere and began at the beginning, right in the *Schools IT 2000* plan. Section 6.4 records that the full-time ICT Advisors to be hired and based in the Education Centres around Ireland and who were to implement the NCTE's various programmes locally were not ICT experts or IT specialists, but in fact nothing more than '*seconded teachers[s] with a proven track record in ICTs*'. This bunch of ultimately 21 pedagogues was to lead and implement the Technology Integration Initiative for thousands of schools and teachers around Ireland. They were admittedly not expert in that field at all – the NCTE Annual Report for 2001 records that briefing sessions were held for the ICT Advisors 'on new technology and its implications for schools', more specifically ICT in special needs education, Dreamweaver and networking. Imagine Computer Network Engineers being seconded to teach in schools without the desired qualifications or experience but with a track record in speaking to groups in rooms!

In fact, these seconded teachers were appointed to local education centres without any shared qualifications in IT or Computer Science, with a range of different experience and abilities, and given a very wide brief indeed. The ICT Advisors who were hired across the country seemed unaware of where their duties began and ended. Some were able to offer a degree of the much needed technical support while others could not or would not, since the role of the ICT Advisor was, according to the report, "primarily concerned with providing pedagogical advice and support to schools and also (though to a lesser extent) technical advice and support."

Schools IT 2000 was itself very unclear on where the actual hard-core technical support and advice was supposed to originate. Section 6.4 lays it at the feet of the full-time ICT Advisor to provide 'training, advice and support on ICTs to all schools within a defined area', although Section 7.1 mentions that the NCTE 'will commission an expert study to consider current and future technology infrastructure options (equipment selection, wiring, deployment of equipment etc.) for schools'. Section 7.3 tells us that the Department's Inspectors will also 'enhance their role in providing advice and support to teachers on ICT issues.' Section 7.4 suggests that technical support 'could be a partnership between a third-level institution and a cluster of schools that included the provision of technical support by the institution.' The

same section records that the 'Scoilnet team will provide technical support in the form of NCTE advice sheets and guidelines for schools, e.g. alternative ICT infrastructure options for schools'. Teachers will be able to 'email Scoilnet and receive timely responses to queries they may have in relation to ICTs'. In fact, everybody but the Minister is being hailed as giving disparate advice and support on ICTs to teachers, but no-one expert and qualified in technology, networking and hardware is being given that specific responsibility as part of a job description. A brief review of the NCTE annual reports uncovers what happened to the technical support issue over the next few years.

3.9 NCTE Annual Reports on Technical Support

The Annual Report for 2001 states that the NCTE ran a telephone technical support line and supported pilot project models of technical support for schools across Ireland which gave 'indications that some benefits accrue from the provision of external technical support to schools', benefits which are neither mentioned nor explained.

The Annual Report for 2002, which followed the publication of *The Blueprint for the Future of ICT in Irish Education*, suddenly targets the 'key role of the school principal in leading ICT in schools' and ICT planning 'at school level'. Busy principals were suddenly handed 'a methodology and a resource pack to enable them to assess their needs and to specify the technology needed to address those needs'. Now unskilled, inexperienced and busy principals were told to go it alone with a resource pack and one or two briefings. Also in 2002, the telephone technical support helpline was discontinued because, it was claimed, schools became more familiar with the technology and demand decreased. This claim is not going to be supported in any way by subsequent research.

However, the Annual Report for 2003 had a heading 'Technical Support' and text that read: 'Feedback from schools including ICT census data has consistently indicated that the lack of technical support in schools is an area of much concern for schools. To help determine the details of this need and to acquire a better understanding of the

schools' technical support issues the NCTE held workshops with ICT Advisors, schools' ICT coordinators and teachers. This feedback will be combined with that from other sources to inform and feed into an overall response to this issue.'

The Annual Report for 2004 began with a boast in its Foreword, 'The NCTE demonstrated its organisational ability to respond in a timely and swift fashion to new ICT-related issues', but the only reference in the rest of the report to technical support is in the lonely sentence, 'In particular, increased access to broadband networks led to demand for more courses in areas such as network management and technical support.' Worse, under a heading *The Role of the ICT Advisors*, the newly defined job description for the first time drops any reference whatsoever to actual technical support.

The 2005 Annual Report makes reference only to a Broadband Service Desk managed by the NCTE. By this time, no-body is giving schools actual technical support on an organised, coherent national basis – it's every Olson Restaurant for itself and widespread disparity sets in.

The 2006 Annual Report continues to refer to the role of ICT Advisors without reference to the earlier 'technical advice and support'. Also, whereas there was occasion to believe in the beginning that the NCTE oversaw or directed the hiring of the seconded teachers on the basis of some qualifications or measured ICT background, in the section headed *The ICT Advisory Service*, a sentence reveals that 'each Education Centre employs and directly manages an ICT Advisor'. How much more difficult this makes it to try to ensure that 21 independent ICT Advisors are singing from a single hymn sheet or are singing at all.

3.10 Conclusion

In this chapter it was shown that early decisions to allow each school in Ireland to go it alone both in planning and purchasing of computers and software created a multiplicity of independent computer sites that defy centralised planning, controls and coherent technical support provision years later and began a digital divide in Irish

Education. In tandem with this failure in planning, the seconding of hobby-computer teachers to oversee the implementation of ICT in schools across Ireland resulted in untrained, unqualified ICT practitioners making a monumental mess of the nation's educational ICT. The NCTE did not so much lose control as fail to grasp it at the beginning, frittering away the opportunity to centralise purchasing, technical support, standardisation and future planning.

4 The Schools Broadband Initiative

4.1 Introduction

This chapter shows that following criticism by the OECD of Ireland's failure to effect broadband penetration, the government responded with the Schools' Broadband Initiative, a Datanet consultancy study which sought to reverse the decentralised free-for-all in ICT by calling for a single, centralised Schools' Network to operate on the HEAnet backbone, a primitive version of a private cloud. However, a critical flaw was placed in the foundation of this futuristic initiative and the flaw was the incorporation of a mess of ISPs to give schools indirect and patchy access to the Schools' Network.

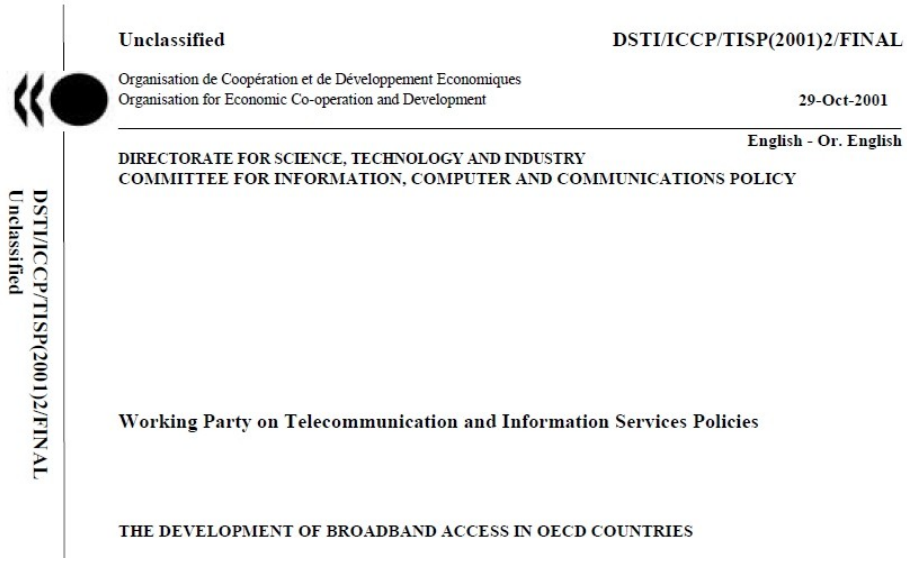
4.2 Modem Ireland

In the National Policy Advisory and Development Committee's study *The Impact of Schools IT2000*, published in 2001, it was recorded that in 1999 the Government had met an earlier target to provide every school in Ireland with at least one multimedia computer connected to the Internet. The Internet connection was of the Public Switched Telephone Network (PSTN) variety meaning that it was enabled by a phone line and a modem. The Department of Education and Science paid for the line rentals and for the first 2hrs of connection for every school. While this allowed statisticians to note that 99% of Irish schools were now connected to the Internet, it was obvious to anyone with an IT background (and to the very patient school users) that this kind of desperately slow single connection was barely adequate to service an individual, never mind an entire school. By 2003, 86% of primary schools were still dependent

on PSTN and the remaining 14% were using the most basic ISDN connection of 128kbps.

4.3 Datanet's Schools Broadband Connectivity Study

Ireland suffered some international embarrassment also in 2001 when the OECD published a report entitled *THE DEVELOPMENT OF BROADBAND ACCESS IN OECD COUNTRIES* where Ireland came 27th in broadband penetration out of 30 countries surveyed. Another OECD report in 2002 entitled *MEASURING THE INFORMATION ECONOMY* showed that Ireland had forged up to 26th place. Other reports recorded that Ireland was bottom of the European Union league table for broadband proliferation. These measurements were seen as likely indicators of future economic performance in a world inevitably moving into the information age and related high-tech industries. Ireland set about cranking up broadband services across the country for business and home users alike.



Unclassified DSTI/ICCP/TISP(2001)2/FINAL

Organisation de Coopération et de Développement Economiques
Organisation for Economic Co-operation and Development 29-Oct-2001

English - Or. English

DIRECTORATE FOR SCIENCE, TECHNOLOGY AND INDUSTRY
COMMITTEE FOR INFORMATION, COMPUTER AND COMMUNICATIONS POLICY

DSTI/ICCP/TISP(2001)2/FINAL
Unclassified

Working Party on Telecommunication and Information Services Policies

THE DEVELOPMENT OF BROADBAND ACCESS IN OECD COUNTRIES

Figure 13 - OECD 2001 Report on Broadband Access

If the Government's biggest failure in ICT was laid down in *Schools IT 2000*, it was about to lay the foundation for what might have turned out to be its biggest ICT success, except that it contained one unseen flaw. In January 2003, as a result of the pressure to compete internationally in the newly-described 'knowledge economy', the Department of Education and Science commissioned an independent telecommunications consultancy, Datanet International, to carry out a study into the provision of broadband Internet connectivity to more than 4,000 schools in Ireland in order to 'evaluate all available options in the provision of broadband Internet connectivity to schools to facilitate an informed decision on an appropriate strategy over the coming years'. It was clear that a highly skilled and educated workforce was a critical part of desired economic success and schools were required to be facilitated with broadband to begin to contribute to an experienced workforce later on (Datanet, 2003, p.2).

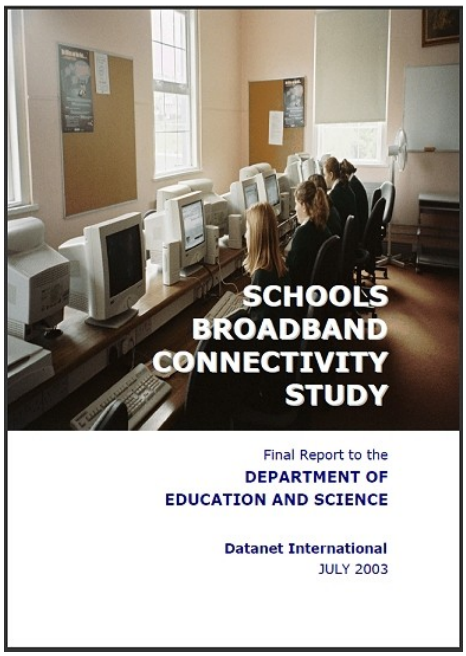


Figure 14 - Schools Broadband Connectivity Study

The Datanet report, entitled *Schools Broadband Connectivity Study*, was concise, clear and expert, since its three authors each had over 20 years of network telecoms' experience. Right from the beginning, and as if anticipating a paper such as this, it argued for a private network that was unknowingly all but invoking the term 'private cloud':

> 'This report recommends that the broadband and ICT requirements of schools be managed in a co-ordinated and integrated manner by the provision of a Schools Network. Schools can be connected to a central backbone providing, in effect, a private network for schools' usage. The Schools Network facilitates centralised management and control over all network functions, including Internet access, security, content filtering, email management and virus control (Datanet, 2003, p.3).'

Here at last was a plea for order where there was disorder, coordinated management where there was decentralised chaos, and a central backbone equitably endeavouring to give every school high-speed access to the Internet with associated safeguards built in, a plea which is as valid today as it was nearly a decade ago. However, this brave new report contained one outstanding contradiction which nobody noticed at the time and which has been handed down to the present day, with all its ramifications.

4.4 Datanet's Schools' Network Concept

Datanet compared the two methods of connecting schools to the Internet via broadband. Firstly, in Section 5.1 of the report, it looked at the decentralised, independent and seemingly easy method of allowing schools to connect via local ISPs of their choice, where quality of service, bandwidth, support, security, anti-virus and content filtering would differ greatly across the country and would not allow for easy accountability or centralised management, not even in terms of cost. Many rural schools might not even be within range of more than one ISP in order to exercise any choice. So, having schools connect to the Internet via a whole lot of different ISPs was declared to be bad because quality of service, bandwidth and support would differ so greatly across the country – this is the critical argument.

Then it looked at its idea to create a centrally controlled and managed 'Schools Network' and network backbone through which all schools might connect to the Internet. This option was regarded as preferable on the following grounds:

- **Management and Control** – a unified approach to the management of the Internet connectivity of all schools at a single point, with central control of applications, security (firewalls, intrusion detection), anti-virus, updates and even content.
- **Support** – network management and monitoring allied to network support and fault analysis from those in control of the network and applied equally to all schools.

- **Content Management** – centralised hosting and on-demand delivery of digital content and applications related to the curriculum, perhaps hosted by Scoilnet servers in due course. [Difficult to believe this far-sighted argument dates from 2003.]
- **Email Management** – a centralised mail server and service for all schools, including SPAM killing.
- **Economies of Scale** – the opportunity to combine schools' various needs to leverage best the possible deals from broadband, backbone and hardware and software providers.
- **Scalability and Future-proofing** – network monitoring of bandwidth usage and possible need for upgrade make possible centralised migration strategies when needed later or even bandwidth increases for individual schools when required.
- **Fund Leverage** – this unusual term refers to the then smart idea to piggyback on existing public-funded network infrastructure to create the network backbone and referred specifically to HEAnet, the Higher Education Authority-funded WAN (the National Education and Research Network), as the most likely candidate to run the backbone.
- **Community Access** – an idea from a decade ago to facilitate community access to the Internet or education resources, which has since then been superseded by widespread home access to the Internet (Datanet, 2003, pp.41-45).

Cost is also greatly circumscribed by the centralising of security issues in one place as opposed to the multiplication of costs involved in replicating security at every single school in the country.

4.5 Datanet's Network Flaw

The futuristic recommendations of the Datanet report included a functional diagram of the School Network concept and a by now familiar (but then prescient) cloud representation of the Internet, but it contains one obvious and critical flaw:

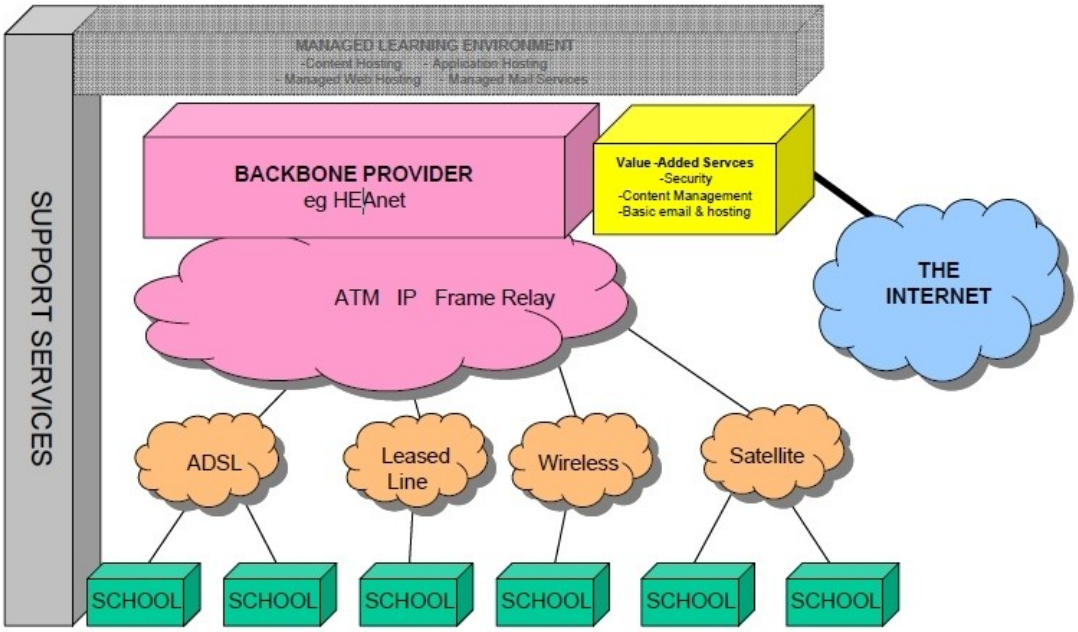


Figure 15 - Datanet School Network Concept (Datanet, 2003, p.31)

The diagram shows the schools as intending to connect to the Internet via the centrally-managed HEAnet backbone in order to avoid connecting to the Internet via a whole parcel of different ISPs – but then it has the schools as connecting to the backbone by a whole parcel of ISPs anyway offering all the difficulties outlined earlier - unpredictable quality of service, bandwidth and support. The critical argument of not using a whole bunch of unrelated, unpredictable ISPs to connect to the Internet is now turned on its head by having the schools attempt to connect to the Backbone by the same bunch of ISPs – this horrible flaw was handed on and has dogged the Backbone experiment to the present day, and no-one has faced the issue since then.

Seemingly unaware of the bug in the plan, the Datanet report endeavoured to explain the important qualitative differences which exist within the various ISPs' elastic term 'broadband provision' prior to making recommendations to the Government.

In order to eliminate PSTN and basic-rate ISDN (128kbps) from consideration, Datanet regarded 'broadband' as referring to every service in excess of 128kbps. In 2003, there were the following options:

- **ADSL** – Asymmetric Digital Subscriber Line, asymmetric meaning that the upload speed may not match the usually higher download speed; a common broadband service on copper wires of the telephone lines; need not interfere with telephone calls occurring simultaneously.
- **Cable** – typically using the cable television (CATV) network, possibly microwave also, enabling very fast broadband, much faster than ADSL.
- **Leased Line** – a dedicated point-to-point higher-performance line usually offering scalable, guaranteed symmetric connectivity speeds, Service Level Agreements, fixed IP address(es), VPN, and QoS; useful for real-time video both ways, VOIP, etc; few or no contention issues; very expensive.
- **Satellite** – available almost everywhere, so covers most isolated rural schools outside ADLS and Cable areas; has lots of problems with latency and contention (explained in next section); relatively expensive.
- **Wireless** – the 802.11b service; sometimes unreliable, subject to contention; limited range from base station, up to 4km; typically up to 2Mbps bandwidth.
- **Mobile Data** (the nascent 3G service) – just about to be rolled out, not tested, supposed to offer asymmetric 384kbps; possibly per usage costs and therefore expensive; contention possible (Datanet, 2003, pp.43-44).

The quality of each of these services, to a greater or lesser degree, is affected by a number of characteristics:

- **Bandwidth** – different services may be typically limited to particular speeds, such as ADSL and Satellite up to 2Mbps; leased lines may be scalable multiples beyond 2Mbps, while fibre optic may be scalable almost limitlessly.

- **Contention** – the number of users per service; 40:1 might denote that your Wireless service may, at times, be shared by up to 40 persons simultaneously, with obvious degradation as a consequence, particularly if everyone is downloading programs or movies. Satellite, Wireless and ADSL may be more prone to contention issues.
- **Latency** – often associated mostly with Satellite service, denoting the time delay between the signal being sent to the Satellite in space and then returning to earth; not helpful in VOIP or video conferencing or in other real-time critical applications.
- **Scalability** – the ability, where necessary or desirable, to increase the bandwidth of a service; fibre optic or leased line might be easily scalable, whereas copper-wire based services may not be easily scalable, particularly where there is considerable distance from the local telephone exchange. Satellite and Wireless may present different problems, particularly with latency and contention.
- **Symmetric**/**Asymmetric** – users often make a request to a server (small upload of data) and then receive a lot more data in response (large file download) in a relation termed 'asymmetric' – the upload and download speeds are not intended to be the same; symmetric broadband provides uploads and downloads at the same speed. Asymmetric broadband has consequences for real-time critical applications such as VOIP or VOIP and video conferencing, gaming, etc.
- **Coverage** – the big issue for Irish schools, many in cities have a plethora of choice of broadband providers, others in isolated rural areas have a choice limited to what can reach them at the end of the Plain Old Telephone System copper wires or satellite connectivity if they can afford the latter (Datanet, 2003, pp.42-43).

A Datanet table summarised the findings on availability of broadband for schools:

Service	Symmetric	Low Latency	Low Contention	Scalable	Non-usage based charging	Availability	Always on
ADSL	No	Yes	No	Somewhat	Yes	Large Towns & Cities	Yes
Cable	Yes	Yes	Yes	Yes	Yes	Very Limited	Yes
Satellite	No	No	No	Somewhat	Yes	Everywhere	Yes
3G Mobile	No	Yes	No	No	No	From mid 2003	Yes
Wireless	No	Yes	No	Yes	Yes	Limited/ Increasing	Yes
Leased Line	Yes	Yes	Yes	Yes	Yes	Almost all schools	Yes

Figure 16 - Availability of Broadband (Datanet, 2003, p.45)

The report concludes that while leased line and cable are clearly most suitable, leased line is too expensive and would probably apply to only 5% of schools and cable has limited availability. ADSL and Wireless are more available in urban areas but both are asymmetric and suffer from contention issues, though they are scalable to different degrees. Satellite, in spite of getting three negatives in a row for symmetric, low latency and low contention, gains traction as the only offering that is available everywhere, particularly for isolated rural schools. In an ideal world, fibre would provide the perfect scalable solution, but is only available in cities/largest towns at this point and is prohibitively expensive.

Datanet pointed out that whatever broadband connectivity route was chosen by Government, it would always have to be seen as liable to and capable of migration to services with higher bandwidth, because bandwidth would always have to increase as more students and more schools used the Internet simultaneously to download multimedia. The aggregated amount of school traffic would only ever increase (Datanet, 2003, pp.27-28). Datanet recommended *initial* broadband provision of between 512kbps and 2Mbps at the very least.

The Datanet Report estimated that, allowing a period of 6 months for the tendering process and agreement from the various stakeholders, the School Network would be up within 18 months (Datanet, 2003, p.3).

Although not within the terms of reference given to them by the DES, the report authors included in an appendix devoted to a number of schools testing satellite pilots a comment which showed that one item continued to appear on the agenda even if no-one wanted to see it: 'Technical support is an issue for all schools. This situation will deteriorate as additional hardware and software are installed and as Internet usage increases (Datanet, 2003, p.48)'. The report authors noticed that no-one in particular was taking responsibility for maintenance of infrastructure inside schools.

Datanet's radical recommendation for a Schools' Network working through a HEAnet backbone was far-sighted in suggesting a centrally-controlled Backbone for Internet connectivity – in order to avoid the mess of different ISPs – but then locks the schools in to using the same mess of different ISPs for connectivity to the actual Backbone, and this contradiction has had many costly ramifications to the present day.

It would have been braver and more farsighted, and ultimately less costly, to recommend fibre connection for all schools directly to the HEAnet Backbone. As Datanet commented, 'Fibre will become increasingly available. Fibre provides the capability to offer truly scalable, high quality, symmetric broadband services. The bandwidth is virtually limitless (Datanet, 2003, p.27)'. So, if the courage existed to recommend a private schools network utilising HEAnet's infrastructure, why not go the whole hog and recommend a radical shift to fibre? Many schools in cities and larger towns could almost immediately have been connected by fibre, and this impetus would have created the pressure necessary to force connection for all the remaining schools in the country by fibre as well. This matter will be explored more fully later.

4.6 Conclusion

In this chapter, the radical and far-sighted Datanet recommendation for a centralised Schools' Network was analysed and found to be wanting in the area of the connectivity proposed. The incorporation of a mess of different ISPs as connectors to the Schools' Network and the failure to urge fibre connections for all schools has created a cycle of regular and expensive bandwidth upgrades and a record of patchy connectivity for schools.

5 High Speed Broadband for Schools

5.1 Introduction

This chapter details the government's plan, in association with IBEC, to deliver broadband access for schools throughout the Republic of Ireland. The Datanet recommendations are being implemented, both the Schools' Network running on the HEAnet backbone and the unseen connectivity flaw at the mess of ISPs. The incredible Norcontel broadband evaluation report is dissected and shown to be very unsound in both its methodology and in its conclusions, greatly understating problems and dissatisfaction among teachers. A conflict of interest involving Norcontel is uncovered.

5.2 Joint Effort for Schools

In July 2004, twelve months after the publication of the Datanet report, the Department of Communications, Marine & Natural Resources, the Department of Education & Science, and IBEC's Telecommunications & Internet Federation, announced a joint agreement to make available a total of €18 million in funds over the next three years to enable the provision of high-speed broadband connectivity to all primary and post primary schools in Ireland by early 2006.

In a remarkable agreement, the Government was going to get off lightly by contributing only €1 million per year, while the various mobile and fixed network Telecoms' companies were going to voluntarily cough up percentages of their profits based on their respective market share to the total value of €5 million per year as shown in the following table, taken from the Memorandum of Understanding/Heads of Agreement on February 24th, 2004:

Estimated Market revenues in Financial Year 2002/03

	€M	Telecoms % Mkt Share		Maximum Notional Fund Contribution
MNO's				Ml.
Vodafone	980	26%		1.30
O2	690	18%		0.92
Meteor	45	1.2%		0.06
Total mobile	***1,715.0***	***46%***		2.28
				-
Fixed				-
Eircom	1,580	42%		2.10
Esat BT	250	7%		0.33
OLO's	200	5%		0.27
Total fixed	***2,040***	***54%***		2.72
		100%		***5.0***

Figure 17 - Annex 1, Memorandum of Understanding, Feb 24th, 2004

It was not that Ireland was particularly beset by obsessively charitable Telecoms' operators – the rationale behind the IBEC/TIF interest in the broadband programme was spelled out in Section 1.1 of the Memorandum of Understanding as based on 'the shared belief that accelerated provision of broadband access to schools is a pre-requisite to the establishment of a knowledge based economy and that such a development is socially, economically and commercially desirable.' Commerce and the national economy needed more highly skilled, educated and IT-savvy college leavers to enter the workforce. Clearly, to make money, one has to spend money.

5.3 The HEAnet Network

The already publicly-funded HEAnet, it was decided, was to create the backbone network and a secured, managed schools network. No-one could complain that the Datanet report's recommendations were not at last beginning to be implemented, even if it was going to take twice as long as Datanet imagined a year before. Also in July 2004, the Schools' Broadband Access Network Request for Tenders was published and gave details of the intended Schools' Network, made up of the HEAnet backbone, the Access Network and the School LANs:

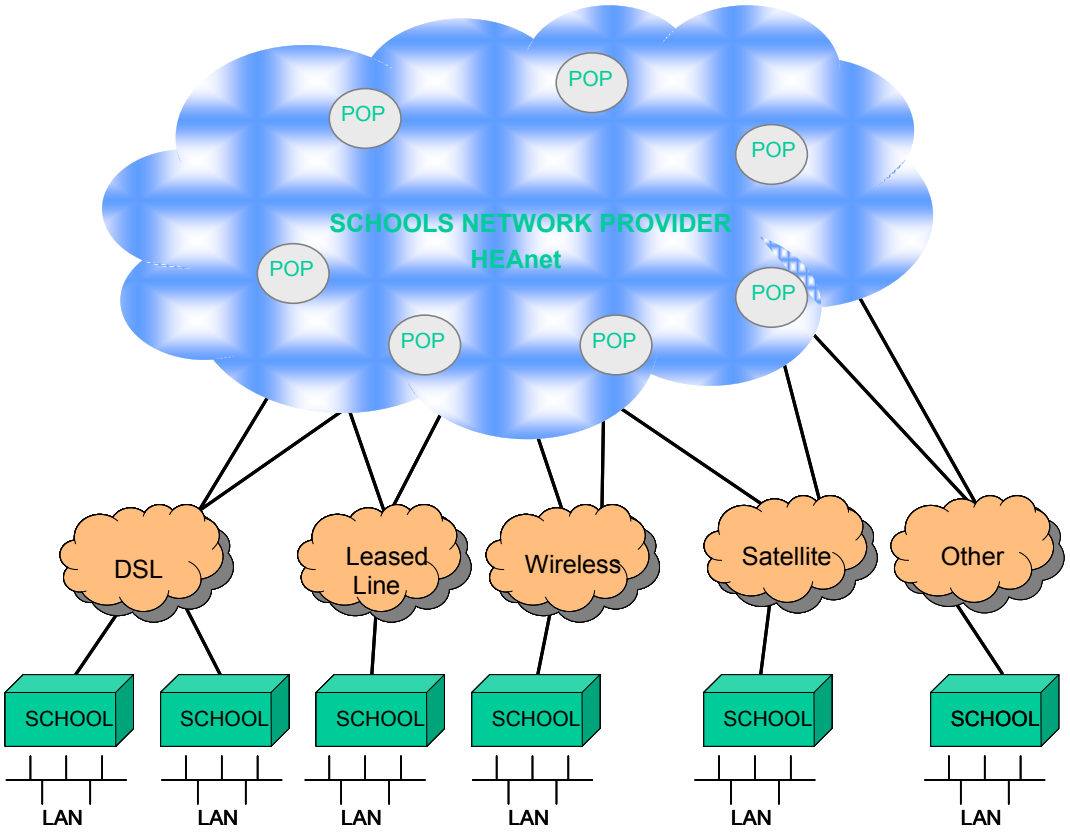


Figure 18 - Appendix 9, p.59, Schools' Broadband Network Access RFTs

The school LANs are shown as connecting to the HEAnet Points of Presence (access points) via the same mess of ISPs as were condemned earlier for direct connectivity to the Internet – now they are being utilised to provide direct connectivity to the Backbone. The logic of this decision is difficult to comprehend.

In effect, the School Network was going to attempt to use a range of ISPs as mere connectors, with no other services being offered or desired. Routers were to be installed in all schools to directly connect the school to the Backbone, as the following figure shows:

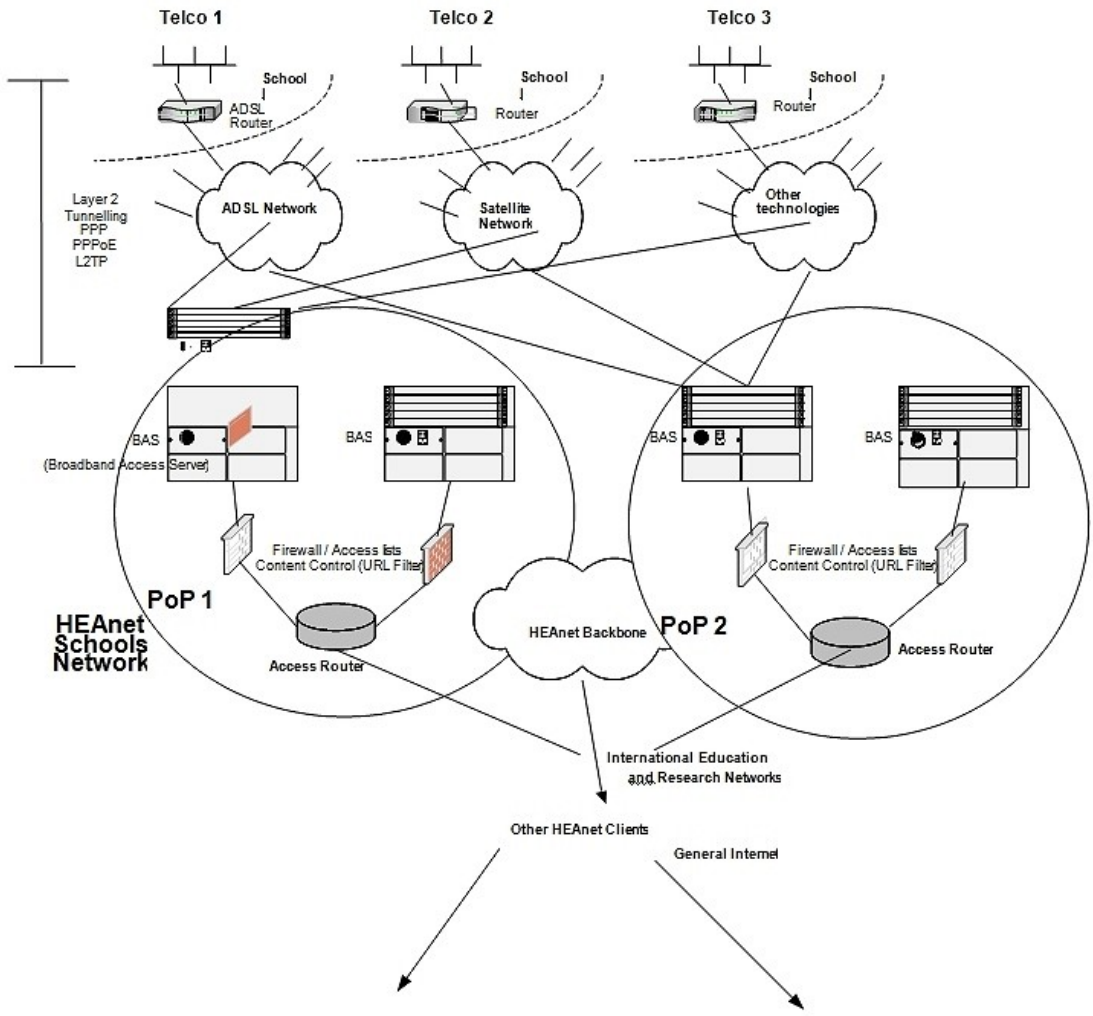


Figure 19 - Appendix 9, p.61, Schools' Broadband Network Access RFTs

The Points of Presence (or access points) were at Cork, Dublin Citywest, Dublin Kilcarberry, Dublin Ballsbridge, Dublin Glasnevin, Galway and Limerick.

Much was made of the speeds inherent in the HEAnet network as depicted in Figure 20 below, but no-one highlighted that these speeds were fairly ornamental since the schools were only going to connect at the speeds variously offered by the condemned ISPs. The reader may well consider how much focus this flaw would later demand in the review of the installation of broadband for schools, a matter which will be examined shortly:

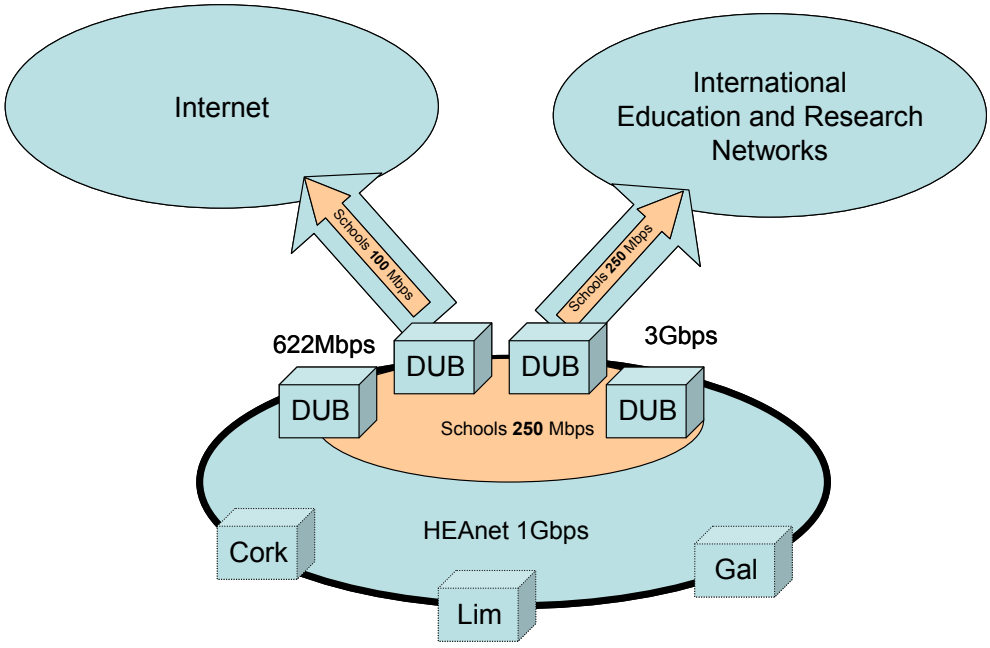


Figure 20 - Appendix 9, p.60, Schools' Broadband Network Access RFTs

Exactly a year later, on July 15th 2005, The Ministers for Communications, Marine and Natural Resources, Noel Dempsey T.D., and for Education and Science, Mary Hanafin T.D., issued a press release about progress toward the Schools' Broadband Access Programme. Following the Request for Tenders a year earlier, contracts were now in place and the awards made were published:

Company Name	Number of Schools Awarded
Digiweb Limited	1,655
Smart Telecom	1,033
Irish Broadband	588
BT Ireland	341
Last Mile	214
HS Data	94
Total	3,925

Figure 21 - Contract Awards

While six different companies were now to undertake provision of broadband access to schools around the country, with all the separate management, oversight, paperwork and standards that entailed, it was decided that it was wiser to offer a single company – Eircom - the contract to install 3,393 routers to avoid any such differentiation and difficult oversight. Clearly, those in charge of awarding contracts could see the argument for centralising, for requiring a single company to undertake a task of great importance to the programme. They still lacked the clarity of vision to comprehend that provision of the actual connectivity itself was of equal if not greater importance

and that a single company might just as well have been charged with undertaking provision of that connectivity via fibre to once and for all cease reports about failures, slowness, breakdowns and need for costly migrations later.

As it was, the six companies listed above were to provide connectivity as follows:

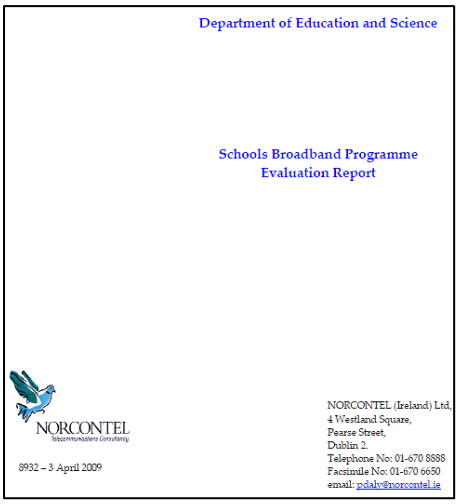
Connection Type	Number of Schools
Fixed Line (e.g. DSL)	841
Wireless	1,507
Satellite	1,577

Figure 22 - Connection Types

It is the view of this report that the decision to rush into provision of expensive broadband connectivity services known to be bedevilled by issues of latency and contention, and that would soon thereafter raise calls for equally costly migration to better services with more bandwidth and fewer problems, was a grave and costly error. Both satellite and wireless connectivity had been highlighted in the Datanet report as having problems with latency, contention and scalability, but now over 3,084 schools were to become entirely dependent on these services. With the Telecoms' companies on side, with the Celtic Tiger in boom, this was the time for some brave soul to cry halt to provision of problematic, second rate connection services that would quickly require migration and to call for fibre across the board, starting with cities and towns first, and moving to the countryside as and when possible.

The press release continued that the companies would begin installation immediately and should complete it sometime around March 2006, but failed to note that the schools were nearly all closed for July and August. Companies were to make their own arrangements with local schools for access, installation and testing. The total cost was now estimated at €30 million over three years owing to provision for a Broadband Service Desk for schools to be managed by the NCTE, and presumably for infrastructure to be undertaken by HEAnet. The only question to be addressed now is whether – against all the warnings and evidence offered by Datanet - the services contracted actually met the needs of the schools.

5.4 Schools' Broadband Programme Evaluation Report


Department of Education and Science

Schools Broadband Programme
Evaluation Report

NORCONTEL

8932 – 3 April 2009

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Figure 23 - Norcontel Report

The Department of Education and Science in 2008 hired Norcontel (Ireland) Ltd. to evaluate the implementation of the Schools Broadband Programme, and in April 2009 received an 86-page document entitled *Schools Broadband Programme Evaluation Report*.

Norcontel was to evaluate 'with particular emphasis on timing, delivery against target, completeness, cost effectiveness and fitness for purpose... the efficiency and effectiveness of the:

- Roll-out of connectivity and router services.
- Technology type / Bandwidth provided.
- Establishment and functioning of National Network and Services provided therein.
- Establishment and functioning of National Helpdesk.
- Performance of contracted Connectivity Providers (Norcontel, 2009, p.6).

The Evaluator was then to make recommendations, keeping in mind the adequacy (or otherwise) of ICT infrastructure and supports in schools and the impact of broadband upon it and the appropriateness of the technologies chosen for schools.

5.5 Report Dissatisfaction

A preliminary reading of the Norcontel report results in some immediate dissatisfaction. Only 59 out of a new total of 3,936 schools were subject to the enquiry, a fraction under 1.5% of schools. Worse, only 59 questionnaires in total were sent out to either the principal or the teacher most involved with ICT. According to the Department of Education and Science publication 'Education Statistics

2006/2007', there were 64,677 teaching staff in total between the primary and secondary sectors. (While Special Needs Assistants are not teachers, they do assist children to use computers where those children need help, and so for the purposes of this paper are included in the number of teaching staff experiencing ICT.)

Number of teaching staff at first and second level

	1996/97	2006/07
PRIMARY		
Primary	21,035	29,534
SNAs	..	7,410
SECOND LEVEL		
Secondary	13,295	13,445
Vocational	6,388	8,749
Community	2,947	3,501
Comprehensive	608	622
SNAs	..	1,416

Data in respect of primary teachers relate to number of teaching posts. Other data relates to whole-time equivalent.
Only teachers paid from funds provided by the Department of Education and Science are included in the above table.

Figure 24 - Education Statistics 2006/2007 (DES, 2008, p.2)

So, the sample is based on only 0.09% of all teaching staff which cannot seriously claim to be representative. Some of the principals requested to answer the questionnaire may in fact be 'walking principals', that is, principals who don't actually teach classes at all. This sample does not do justice to the complexity of the number of schools and the number of teachers experiencing ICT and the new broadband service.

Furthermore, the questionnaire is insufficiently quantitative – the questions ask a single teacher to capture an entire school's experience based on his or her *feelings* about the past year or more expressed merely by choosing a number between 1 and 5:

Broadband Evaluation Questionnaire					
Date :		Respondent :		Interviewed by :	
Section A General Impressions					
1	For how long has your school been participating in the Schools Broadband Programme ?			_____	
2	On a scale of 1-5, where 1 is 'very poor' and 5 is 'very good' how would you categorise elements of your overall impression of the Schools Broadband Programme to date?				
	- quality of information on the Programme provided[1)] to the school				_____
	- Service Desk (Help Desk)				_____
	- impact on school activities				_____
	- if impact was 'poor' or 'very poor', why is this so? _____				
	- the overall Service				_____

Figure 25 - Norcontel Report, p.75.

One teacher, trying to speak for all the other teachers in the school, is required to try to capture in a scale of 1 – 5, whole numbers, the adequacy of the bandwidth provided to the school?

Bandwidth Provided				
23	What bandwidth has been provided to the school for Broadband access		_____	
24	Were you consulted on the bandwidth needs of the school		Yes	No
25	If "No", was this acceptable to the school ?		Yes	No
26	On a scale of 1-5, where 1 is 'totally inadequate and 5 is "fully adequate" how would you categorise the adequacy of the bandwidth provided?		_____	
27	What is the reason for your score? _____			

Figure 26 - Norcontel Report, p.76.

All the experiences, failures, satisfactions, stressful moments are to be compressed into a number? How is this subject to any useful analysis later by researchers? The numbers do not decompress to provide any useful data at all. Did students manage to make a video call to students in another class abroad? Could two classes of students simultaneously download multimedia at an acceptable rate? When a number of classes were surfing, did the network seem to crawl? How does this appear from the number 2 or 3?

The questionnaire asked for whole number grades for various elements of the service users' experience. On page 16 of the report, Norcontel then offers a somewhat confusing explanation of the grading scheme as follows:

Average Grade Band	Rating	Equivalent % Grade (Approx)
4.5 – 5	Very good	88% - 100%
3.5 - 4.5	Good	63% - 87%
2.5 - 3.5	Fair	38% - 62%
1.5 - 2.5	Poor	13% - 37%
1 - 1.5	Very Poor	0% - 12%

Figure 27 - Norcontel Report, p.16.

In an ideal world, their grade categories would be unique, but in this case, 1.5 can be both *Very Poor* and *Poor*; 2.5 can be both *Poor* and *Fair*, etc. It is surely more than quibbling to insist that they could have made the categories unique by simply using 1 – 1.4 and 1.5 – 2.4, etc.

Too much reliance is placed on a busy principal or teacher not only to rate the link adequacy going back a year or more, but also to remember the number of failures and also the average time to repair them in days. What teacher carries around in his or her head this kind of data? With reference to this part, the report adds helpfully: 'This indicator is based on the recollection of the respondents of fault rates and restoration times; a log of these events is not generally kept by the schools.

A more accurate insight into service availability is given later in the report, based on Service Desk logs and statistics (Norcontel/DES, 2009, p.10)'. Why not just promote the accurate quantitative data with regard to link failures when it is clear one teacher cannot speak for all of the other teachers and remember a totality and compress it into a scale of 1 – 5?

29	On a scale of 1-5, where 1 is 'totally inadequate and 5 is "fully adequate" how would you rate the performance of the link in the following areas?	
	- Reliability	_____
	- Speed (perception of 'fast' or 'slow")	_____
30	In respect of "Reliabiity", can you provide the following ?	
	- Number of failures in past year	_____
	- average time to repair (days)	_____

Figure 28 – Norcontel Report, p.76.

5.6 Report Methodology Undermined

In fact the report undermines its methodology by admitting that respondents couldn't recall the details requested: 'The elapsed time since installation of the service in most schools meant that many respondents commented that they did not recall the process and its documentation in detail; nevertheless, it was felt that significant problems would have been remembered (Norcontel/DES, 2009, p10).' Respondents are being required to give a number in spite of trying to tell the interviewer they don't remember the details sufficiently to generate an accurate number...

The earlier Datanet report's predictions for the quality of broadband provision were entirely vindicated by Part 3 of Section 1.5 Review Findings:

> 'The key cause of dissatisfaction was inadequate bandwidth, the bandwidth receiving an overall fair rating. There was a general consensus view that the bandwidth provided did not always match the schools requirements and consequently the service was, on occasions, perceived as being 'slow'. In extreme cases, this severely limited what could be achieved in class using the service. There was a preponderance of negative comment on bandwidth from schools which had a satellite service, 39% reporting a poor or very poor service. Corresponding figures for wireless and DSL were 16% and 21% respectively (Norcontel/DES, 2009, p.9).'

The responses 'poor or very poor' are lumped together to form 39% so that a reader or researcher is unable to tell what precise percentage reported the satellite service as

'very poor'. If 'the key cause of dissatisfaction was inadequate bandwidth' how then did Norcontel feel about persisting in stating that the bandwidth received 'an overall fair rating'? This rating scale is clearly inadequate to express the gradations of dissatisfaction and is inclined to cause responses to be clumsily clumped together and then described a shade too positively.

For all the inadequacies of the report, some facts nevertheless erupt with singular force:

> 'While nearly three quarters of schools (70%) rate service availability (link reliability) as good or very good, 30% rate it as fair to very poor. This latter group suffer from regular* problems which continue to evade resolution. Schools with service over satellite had the most problems, many of these of a 'permanent' and repetitive nature. Three out of five schools reported at least one access link failure in the last year. A total of 124 service failures were recorded for the 59 schools surveyed, giving an average of 2.1 link failures per school in the previous year. Fifty two out of the 124 service failures can be attributed to 5 schools (Norcontel/DES, 2009, p.10).'

124 service failures per 59 schools can be scaled up to something like 8,184 link failures for the 3,936 schools in Ireland. The Norcontel report never expands the results of its minute sample and scale to the real number of schools on a national scale where it might have legitimately warned Government that approximately 39% of schools – some 1,570 of them - might be rating service availability (link reliability) as 'fair to very poor' – this is a disastrous outcome for the broadband scheme, but Norcontel avoids any such comparisons. Why does it persist in joining 'fair' to 'very poor'? If this was a weather report, fair weather would be fine and very poor weather would be absolutely terrible... Fair here is actually a negative quality, but is inclining the reader to suppose it is not too bad at all. For those suffering 'very poor' link reliability, a further description is offered later: 'This latter group suffer from chronic* problems which continue to evade resolution (Norcontel/DES, 2009, p.24)'. It is clear that this line was softened for inclusion above on page 9 where the word 'chronic' was changed to 'regular'. Many readers only read the executive summary.

If 52 link failures could be attributed to 5 out of 59 schools, then on a national scale 7% of schools might report that number of failures: 'For schools experiencing at least one link failure, the reported cumulative duration of service loss per annum was estimated to be 6.8 calendar days (Norcontel/DES, 2009, p.10)'. Norcontel has to be credited for giving a further head-scratching layer of confusion to the few quantitative statistics on offer - since the calendar days referred to in the report are composed of 24hrs, whereas the actual primary school day is in the region of 5 hours teaching time, a calendar day of lost time must equal in the region of almost 5 teaching days; in this case since each school might have lost 6.8 calendar days, that is somewhere in the region of 34 teaching days in total and since schools are open approximately 40 weeks per year, then they are without broadband in the region of nearly 7 weeks per year or 17.5% of the time if the calendar days don't refer to weekend days (not clear in the report) or else 5 weeks or 12% of the time if the calendar days do refer also to weekend days. In either case, 7% or 275 schools in Ireland must be regarding this as a Schools *Non*-Broadband Programme. No business in the commercial sector could be expected to accept this level of service breakdown.

However, as the Norcontel report helpfully shows in *Section 6.2 Service Availability*, further ahead on pages 66 – 67, the above data about occasions and durations of service loss was greatly under-remembering and underestimating the actual facts. The Service Logs portrayed a much worse scenario:

Reported Fault Rate per 100 lines per year	DSL	Wireless Local Loop	Satellite	LLU	Leased Lines
	20	38	31	77	61

The fault rate is significantly higher than anticipated especially for wireless local loop, local loop unbundling, and for leased lines. This fault rate is also higher than the perceived rate reported by schools during the survey. The tabulated rate above is the more accurate, being based on Service Desk logs; the survey reported rate was not based on records but on the recollection of the interviewees.

Figure 29 - Norcontel Report, p.66.

If there is such a large disparity between memory and statistics, why not prioritise the admittedly accurate statistical logs of service failures at the front of the report, instead of burying them on page 66, and thereby avoiding promoting the admittedly false

figures arising from recollection and the associated rigmarole of the conversion of calendar days to school days? The times required to achieve restoration of downed services were also much worse in the accurate statistics:

Restoration Time for a faulty line	DSL	Wireless Local Loop	Satellite	LLU	Leased Lines
	20 days	9 days	11 days	25 days	10 days

The restoration times are also much longer than anticipated; on average it takes just under three weeks to restore a DSL line and over a week for a wireless local loop line.

Figure 30 - Norcontel Report, p.67.

Furthermore, the days referred to in the figure are 'calendar days' of outage, meaning that they add up to many more school days. In other words, for many schools the service is offline for weeks at a time.

5.7 The Bandwidth Block

The bandwidth block at the mess of ISPs' access points is such that it impacts on the ICT activities in the schools: 'The usage rate was low for other (real-time) applications for which the network generally imposes a constraint. Videoconferencing was such an application which had been trialled by a small number of schools as part of a school-twinning exercise but was abandoned due to the poor quality of the video and audio' (Norcontel/DES, 2009, p.11). Videoconferencing abandoned is a disaster! Clearly, it matters little what speed the HEAnet network is whizzing at if all of the schools are essentially being blocked by domestic speed ISPs' broadband at the access points.

This creates the very real likelihood that many schools with other, better broadband access opportunities have 'stepped outside' the Schools Broadband Network entirely because it's way too slow, with more schools hoping to follow. This was hinted at in the Norcontel Report: '19 schools have refused the service offered on the basis that their existing broadband service is preferred or because of concerns regarding the particular service offered' (Norcontel/DES, 2009, p.8). In Section 2.6.1.2 of the report

some more detail is offered: 'In providing an overall fair rating, the general consensus amongst respondents was that the service was permanently 'slow' or 'frequently slow'. One school had ceased using the service altogether, while one second-level school had made alternative private arrangements to cater for higher bandwidth services to meet the size of its particular demand... Twenty five schools (42% of the survey) rated the bandwidth as being less than good and not adequate to their needs (Norcontel/DES, 2009, p.23).'

42% of schools in the admittedly minute sample condemning the bandwidth means that, scaled up to the real national figure, 1,968 schools might condemn it. This tallies with hearsay from IT professionals in the Dublin area who service schools and who report conversationally that many schools have opted out of the Schools Network scheme to achieve faster broadband speeds. The critical flaw in the broadband plan highlighted a number of times earlier in this paper – namely the mess of ISPs condemned as inadequate for Internet connectivity but acceptable somehow for Backbone connectivity – is imperceptibly described in the Norcontel report: 'The access link element of the schools broadband network, which is the responsibility of the access service providers, currently exhibits poor levels of availability; that is, a high level of outages. This increases costs for the Department and will inhibit the further integration of ICT into the classroom (Norcontel/DES, 2009, p.15).' *A high level of outages* means the entire project is at risk.

In light of the 42% of schools unhappy with the broadband, it is stretching credulity to believe *Section 4.6 Network Architecture* when it offers the following conclusion: 'The evaluation concludes that this is an excellent arrangement, ensuring that each school is securely integrated into the network, *isolated as far as possible from the vagaries of service providers*, and from any issues with other schools' networks, and provided with relatively secure data transfer (Norcontel/DES, 2009, p.56).' On the contrary, the schools are entirely caught in the choking web of vagaries of service providers. This is an example of how a report can stand facts on their heads.

It causes some perplexity that Norcontel can stand over the use of the phrase 'overall fair rating' to describe this amount of broadband dissatisfaction. Section 2.6.1.2, *The Broadband Service – Adequacy of Bandwidth Provided* ends with the single sentence:

'All schools surveyed would happily accept more bandwidth (Norcontel/DES, 2009, p.23)' at which point one wonders if this particular situation is being taken entirely seriously.

5.8 Simple Visual Inspections

With regard to the Norcontel report's requirement to check the adequacy of the ICT infrastructure in the 59 schools, it describes its methodology for this task as follows:

> 'While visiting the school, the opportunity was taken to form an opinion of the adequacy of each in-school network to complement the delivered broadband access and the support available in respect of the overall ICT environment in the school. Of necessity, this review was not a full-scale network audit; an opinion was formed, *based on a simple visual inspection of network components, closets, IT cabling*, and on the ability of the network to take maximum advantage of the broadband service and the reliable delivery of applications across it (Norcontel/DES, 2009, p.17).'

A *simple visual inspection* doesn't cut it; an audit of the school LAN would require a systematic inspection of the server(s) and associated CPU(s), OS, RAM, hard disks, log files (for past problems) and service records, computers, router(s), switches, cabling, and tests of different types of downloads, uploads, applications and file operations within the network, etc. It is simply impossible to form an opinion of the 'ability of the network to take maximum advantage of the broadband service and the reliable delivery of applications across it' by a 'simple visual inspection'.

The result of the simple visual inspection of the 59 schools was summed up by Norcontel as: 'The quality of the installation practice was generally good, being below standard in only 3 of the 59 schools inspected... Some schools deployed computers that were obsolescent or network switches of low quality which were prone to service failure or presented bandwidth choke points (Norcontel/DES, 2009, p.37).' The number of schools which deployed obsolescent computers and low quality network

switches that presented bandwidth choke points is, apparently, a secret. Below standard in 3 of 59 equates to below standard in 5% of all schools in Ireland, which might therefore be nearly 200 schools having below standard network infrastructure. This should be in headlines somewhere in order to energise an upgrade but instead is downplayed in the report.

5.9 Conflict of Interest

A trawl of the Dáil record for 2008 uncovered that on Thursday, 11th December, Dublin Mid West Labour TD Joanna Tuffy asked Minister for Education and Science Batt O'Keefe for details of all contracts to consultants for preparation of reports of any kind, how much was paid and to whom during the years 2007 – 2008.

Minister O'Keefe's written answer contained a number of tables and the table for 2008 to the end of October includes details of the two most expensive contracts for that year:

Year 2008 (to end October)

Name of consultant	Purpose	Total Cost €
Professor Iseult McCarthy	Review thresholds re award of higher level qualification allowance for specialist teachers	14,096.46
Sean McCann	Review thresholds re award of higher level qualification allowance for specialist teachers	3,853.33
John McGinty	Review of Co-operation Hours Committee meetings	14,424.22
Patrick Dowling	Review Co-operation hours with other institutions	18,223.92
Insight Statistical Consultancy	Analysis of Dept's Guidance Questionnaire for Senior Cycle Students in Post primary Schools 2006/2007	4,970.68
Pat Ryan	Review of Co-operation Hours Committee meetings	16,196.91
Arthur O'Hagan Solicitors	Professional fee for Section 105 Inquiry re Peter Gargan 1/01/07 to 25/04/08	5,656.75
Horwath Consulting Ire Ltd	Development of a National English Language Policy & Framework for Legally Resident Adult Immigrants	29,474.50
Eco Unesco	Development of an education for sustainable development strategy	23,305.00
Sean Connolly	Member of Steering Group — Review of Service Delivery Capacity of IT Unit	1,566.00
Deloitte & Touche	Review of the Service Delivery Capacity of the IT Unit	27,860.25
Bearing Point	Learner Database Advisory Project	26,379.69
Centre for Cross Border Studies	Research/report on Southern Postgraduate Students attending NI Higher Ed. Instutions	6,030.00
ESRI	Provide assistance in identifying the geocordinates of a number of outstanding schools	2,359.50
Norcontel (Ireland) Ltd	Programme Evaluator — Schools Broadband Access Programme	56,958.19
Norcontel (Ireland) Ltd	Technical,commercial & financial advice — Schools Broadband Access Programme	57,414.50
Colgan & Associates	Provide research services re set up process for Special Education Appeals Board	31,780.00
Total Cost		340,549.90

Figure 31 - Dail Debates Written Answers 8th July 2010

The written answer seems to show that Norcontel was paid €57,414.50 for technical, commercial and financial advice related to implementation of the Schools' Broadband

Access Programme, and also simultaneously paid €56,958.19 as independent Programme Evaluator for implementation of the Schools Broadband Access programme. This is hardly credible – an IT company is paid to help implement the Schools Broadband Access Programme and is also paid to undertake 'the key objective... to provide *an independent analysis* of progress and developments in the programme to date'. It need hardly be said that this represents a serious conflict of interest and greatly undermines the credibility of the report. How can the Government make the best decisions for schools when it is paying money not to receive the full facts?

In Section 5.4 Conclusions, the report contains one view that mirrors the Department of Education and Science and IBEC-TIF decision to award the deployment of the routers to a single company, Eircom:

> 'A key issue mentioned above is the number of contracts awarded. A lesser number than the seven that have been awarded in the first phase of the Programme would ease many of the contract formulation, implementation coordination and subsequent service management issues encountered. Notwithstanding the choice of technologies offered by multiple service providers, the reduction of the number of service providers, ideally to one consisting of a consortium or a single operator, should be an objective of the Programme (Norcontel/DES, 2009, p.65).'

This study has argued that if the mess of ISPs was inadequate to the task of providing Internet connectivity for a whole host of reasons, then it was surely equally inadequate to the task of providing that most important connectivity to the HEAnet backbone. A single operator of sufficient size should have been appointed to effect fibre rollout to all schools in Ireland once and for all to connect them directly to the HEAnet backbone, a matter which will be addressed in full later.

5.10 Norcontel Summary Findings

Following the decoding of the Norcontel report above and the highlighting of the degree of negativity and failure in the Schools' Broadband Programme, it is instructive to look at how Norcontel presented the overall review findings in the executive summary on page 9:

Parameter	General Rating by Schools	Average Score out of 5	Percentage of Schools rating Parameter as Good or Very Good
Overall Satisfaction with the programme	Good	3.6	58%
Service Desk rating	Good	3.9	76%
Impact of Broadband on schools activities	Good	3.9	73%
Quality of information form the Department	Good	3.5	53%
Adequacy of bandwidth provided	Fair	3.3	49%
Link Availability	Good	3.7	70%
Content filtering	Good	3.7	65%
Firewall service	Very Good	4.5	96%
Anti-virus measures	Good	4.3	82%
Overall quality of support	Good	3.8	73%

Figure 32 - Norcontel Report, p.9.

It is not the healthy who need the doctor, but the sick. Attention should be drawn to the critical deficits with a view to having resources applied to make up what is lacking.

The Norcontel report is flawed and overly reductionist in not giving a true picture of the many obstructions blocking the Schools' Broadband access programme.

5.11 Conclusion

This chapter endeavoured to decode the facts from the complicated and labyrinthine Norcontel evaluation report on the Schools' Broadband programme. It highlighted obvious issues undermining both Norcontel's methodology and its softened findings

as well as a conflict of interest in its role as 'independent evaluator'. As evidenced earlier, the mess of ISPs being used as mere connectors to the Schools' Network were proving to be a major obstacle to the effective use of ICT in schools.

6 EC Broaches Schools' Discontent

6.1 Introduction

This chapter notes that the European Commission finally breached the truth barrier about the condition of ICT in Irish schools in its Empirica report, particularly in relation to Ireland's ranking in broadband provision for schools and in teacher satisfaction with ICT.

6.2 Empirica Knowledge

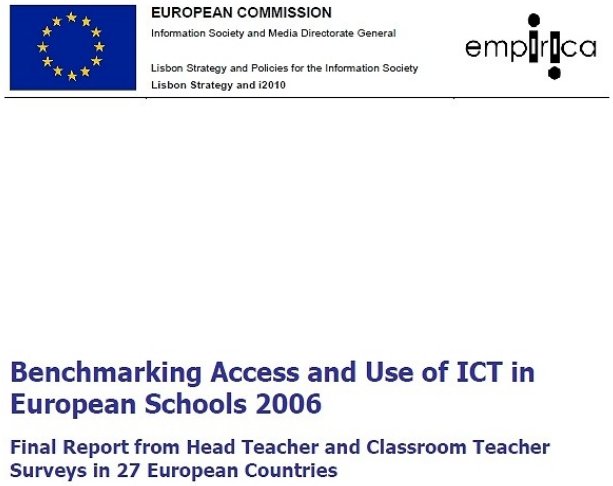

Figure 33 – EC/Empirica Benchmarking.

During the greater part of this study's research, it was appropriate to consider the study's patron as most appropriately John the Baptist because the paper was crying in the wilderness about technology deficits such as obsolete computers, very poor broadband connectivity and the complete absence of technical support in schools, allied to poor planning and a series of reports and evaluations that understated the problems affecting ICT in Irish schools. It was disputing the authorities' rosy views, among them the NCTE reports and that of Norcontel. And then along came a number of salvific studies that quite suddenly, without warning, highlighted years of problems affecting ICT in Irish schools.

In September 2006 the European Commission's Information Society and Media Directorate General (part of *Lisbon Strategy and i2010*) published a study by Empirica entitled *Benchmarking Access and Use of ICT in European Schools 2006 - Final Report from Head Teacher and Classroom Teacher Surveys in 27 European Countries*. This ran to 461 pages and so sub-reports, called Country Briefs, were also published for each member state. The Irish one was called *Use of Computers and the Internet in Schools in Europe 2006 – Country Brief: Ireland* and ran to 11 pages.

For the purpose of comparison with the Norcontel report which was based on a questionnaire to 59 teachers, the EU/Empirica study questioned 403 head teachers and 626 classroom teachers through the services of TNS mbri (Market Bureau Research of Ireland).

It's hard to believe that the NCTE and Norcontel missed its startling conclusions. Apart from showing that Ireland ranked 20th out of 27 countries for broadband access in schools:

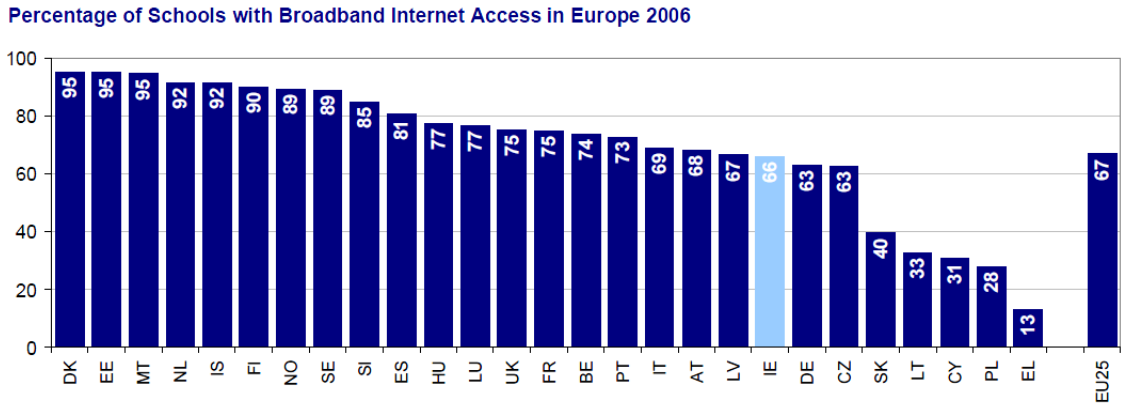

Figure 34 - EC/Empirica, p.6.

The report finally breached the apparent 'D' Notice on publicising discontent in schools on its first page in a section headed *Key Findings*:

> 'However, Ireland ranks *at the very bottom in Europe* when it comes to teacher's satisfaction with the ICT infrastructure in their schools. Despite the fact that all Irish schools are equipped with some computers and have an internet access, a

major problem seems to be the still insufficient ICT equipment and access to the internet in Irish schools indicated by 34%. Also, a very high 85% wish there were better support and maintenance actions taken. In particular teachers in primary and vocational schools state this as an issue (EC/Empirica, 2006, p.1).'

This is the first official backing for the more sceptical approach of this study. Also on its front page, under a heading *ICT Equipment and Internet in Schools*, the report shows the digital divide alive and well in Ireland contrary to a stated tenet of *Schools IT 2000*: 'There is also some variation with regard to broadband access between urban and rural areas: 70% of schools in densely populated areas have broadband access compared to 56% of schools in thinly populated areas (EC/Empirica, 2006, p.1).' The report continues that with regard to the 'very high 85%' wishing for better IT support and maintenance, the situation only seems to be worse in Latvia and Malta.

A more damning blow to Ireland's ICT in Schools self-image is expressed in the following figure:

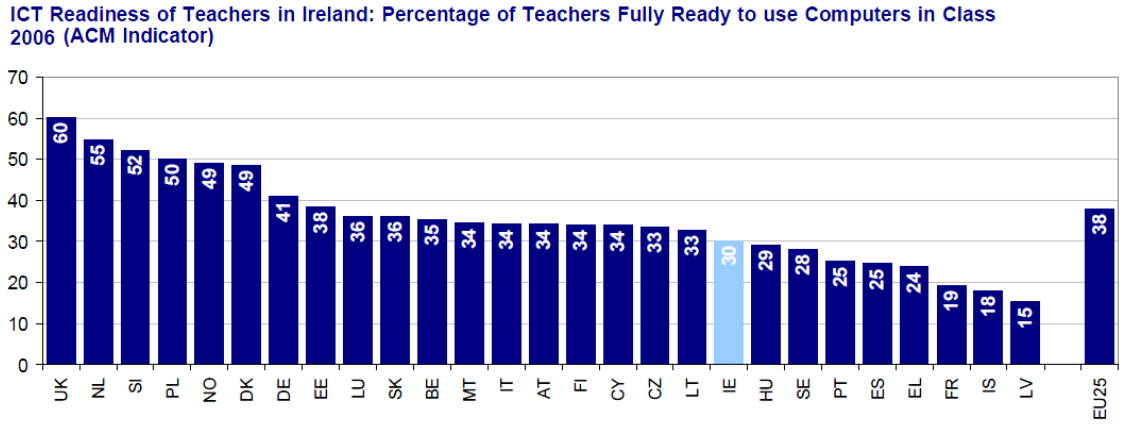

Figure 35 - EC/Empirica, p.7

Between insufficient ICT in the classrooms and the lack of working access to the Internet, only 30% of Irish teachers feel fully ready to use computers in class. This puts Ireland in the 'bottom half' of European countries with regard to ICT readiness of schools and teachers, a very different picture than that conveyed by the body charged with implementing ICT in Irish schools, the NCTE in its annual reports.

At last the information genie is out of the bottle and sceptics can legitimately begin to question the accuracy of the years of self-congratulatory reports and evaluations that show every school connected and doing nothing less than 'good' to 'fair' and with no particular flaws in the long-term planning of ICT in Irish schools.

6.3 Conclusion

This chapter detailed the EC Empirica report exploding years of self-congratulatory mythology about the 'success' of ICT in Irish schools, greatly embarrassing Ireland internationally and at home.

7 Irish Government Response

7.1 Introduction

This chapter follows the Irish government's reaction to EC criticism by creation of a rather education-oriented Strategy Group and claimed major investment over a 6 year period to drive ICT in schools. The Strategy Group's report is analysed for blindness to the facts and to expert technical knowledge, though it does admit, while blaming everything on a lack of investment, that broadband blockages are the major obstacle to the success of ICT in schools. The NCTE is shown to have totally mismanaged its role.

7.2 The Final Strategy

Not long after the EC/Empirica report, on February 25th 2007, the then Minister for Education and Science, Mary Hanafin T.D., announced the appointment of a Strategy Group to advise her on the prioritisation of measures relating to a planned Government investment of €252 million in ICT in schools.

The investment was intended to cover the period 2007 to 2013 as outlined in the Government's National Development Plan published the month before. This was going to be a critically important piece of advice since it was going to greatly influence the NDP investment and the next five years in Irish schools.

The Minister stated that the new plan for ICT in schools would address, among other things, 'the maintenance of a national broadband network for schools, technical maintenance and support requirements and the upgrading and renewal of hardware along with the provision of software and digital content for learning (DESb, 2008, p.36).' The Minister noted that the investment and the success of the ICT in Schools' project was critical both for the learning and development of students themselves, but also for the competitiveness of Ireland into the future in the new global knowledge economy.

7.3 Ministerial Strategy Group

The Minster's Strategy Group was composed of ten persons, two school principals and a school ICT Coordinator, a person each from UCD, Intel, Iona Technologies and the Digital Hub, and a number of civil servants and was chaired by the Director of the NCTE. Its methodology was to receive invited written submissions and some requested oral presentations for any clarifications they required. There were 35 written submissions and later some 17 oral presentations, the written ones almost exclusively from education partners:

Written submissions

An Chomhairle um Oideachas Gaeltachta & Gaelscolaíochta
Association of Community and Comprehensive Schools
Association of Management of Catholic Secondary Schools
Association of Principals of Vocational Schools and Community Colleges
Association of Secondary Teachers Ireland
Association of Teachers/Education Centres in Ireland
Catholic Primary School Management Association
Computer Education Society of Ireland
Discover Science & Engineering
Forfás
Froebel College of Education
ICT Advisors Association
ICT Ireland
Irish National Teachers' Organisation
Irish Primary Principals' Network
Irish Vocational Education Association
Leadership Development for Schools
Marino Institute of Education
Mary Immaculate College
Mater Dei Institute
National Association of Boards of Management in Special Needs
National Association of Principals and Deputy Principals
National Centre for Guidance in Education
National Council for Curriculum and Assessment
National Council for Special Education
National Parents Association for Vocational Schools
National Parents Council (Primary)
Open Ireland
St Angela's College of Education
St Patrick's College of Education
State Examinations Commission
Teachers' Union of Ireland
Technology Subjects Support Service, t4
The Library Council of Ireland
Union of Secondary Students (Ireland)

Figure 36 - Strategy Group Written Submissions

If the Strategy Group had invited a similar number of submissions from industry technology partners, the subsequent report would have been greatly enriched by practical knowledge and solutions, as opposed to pleas for engagement by industry and greater government spending, matters which will be addressed later.

7.4 Strategy Group Report

On July 10th 2008 Batt O'Keefe, newly appointed Minister for Education and Science, published the report of his recent predecessor, Mary Hanafin, entitled *Investing Effectively in Information and Communications Technology in Schools, 2008-2013*.

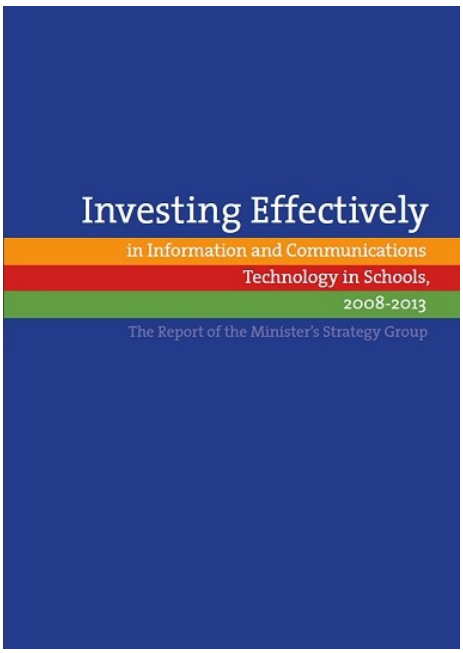

Figure 37 - Investing Effectively

For all its education partners' bent, this report begins with a style different to anything that has come before in Ireland, with a forthright, direct tone and a capacity to highlight issues obstructing progress with ICT in schools. Right in the executive summary it declares that in order to

achieve the desired level of ICT in schools, a number of critical and interconnected factors must be addressed, including 'sufficient computers and supporting ICT equipment in schools, adequate and robust broadband provision and technical support and maintenance of a high standard' or, it continues dramatically (and using a line uttered elsewhere in this study), 'the entire project is at risk'. In broad brushstrokes, the report highlights 7 investment objectives critical to success of the ICT project:

Seven investment objectives and related recommendations
1. Continuing professional development
2. Software and digital content for learning and teaching
3. ICT equipment – additional and replacement
4. Schools broadband and services
5. Technical support and maintenance
6. Implementation structures and supports
7. Innovative practice and research

Figure 38 - Investing Effectively, p.11.

While 3 out of the 7 objectives relate to hardware, support and infrastructure, the failure to engage with industry technology partners in the consultation stage results in no singular, imaginative and new solutions to the old problems soon to be outlined, but instead harks back to more money splurged on soon-to-be-obsolete hardware purchases and avoids dealing with the critical flaw in the plan to date, the choking, strangling incorporation of a mess of ISPs at the access points to the Schools' Network.

The report has three sections:

- ICT in schools – the current context
- The future
- Objectives and priority recommendations for ICT investment

In establishing the current context, the report begins by looking at some of the documents referred to earlier in this study - *Schools IT 2000* and *Blueprint for the Future of ICT in Irish Education* and various NCTE census-related publications - and then laments what it refers to as the lack of research material relating to the real ICT status in Irish schools, 'there is much less available by way of authoritative system-wide study (DESb, 2008, p.5).' The EC/Empirica report gets honourable mention and finally the bad news is revealed in Ireland for the first time and signed off by a Government Minister:

> 'Ireland ranks at the very bottom in Europe when it comes to teachers' satisfaction with the ICT infrastructure: 85% of Irish teachers wish there was better support and maintenance for ICT in our schools. *Schools do not have access to a basic level of equipment and technical support to enable ICT integration to take place* (DESb, 2008, p.6).'

Not only is the situation very bad, contrary to all of the NCTE reports to date, but ICT integration is ***not currently able to take place***. It must have been very difficult for the Director of the NCTE to hear this on a group which he was chairing since it pointed to a failure by the NCTE to implement ICT in Irish schools going back a decade; the hiring of teachers to act as ICT Advisors offering technical support had utterly failed; the use of a plethora of ISPs to create access points to the HEAnet Schools' Network had utterly failed. The failure to set requirements for the purchases by schools of hardware and network infrastructure from the beginning had led to a loss of design and control. Educators don't cut it in matters of technology and infrastructure, whether they are Headmasters or ICT Advisors, although they clearly do cut it in matters of pedagogy.

There needs to be a separation of Education and ICT Provision – let the teachers teach and let the IT professionals plan and provide for ICT services, preferably transparently to the educators. The educators' quixotic adventures in IT-land had come to a bloody end. However, this was not yet fully apparent to the Minister's Strategy Group as evidenced by the overwhelming number of invitations to educators to make written submissions for the 5-year plan, and the almost complete absence of invited submissions by any ICT network, technology or industry professionals. At the

end of the Ireland ranking quotation (above) in Section 2.1 of the report, an '*In Brief*' summary provided for report readers claims that recent programmes for ICT in schools have actually been successful and retreats into denial of responsibility, resorting to blaming lack of investment and funding:

> **In brief: recent programmes for ICT in schools have been successful but this success has been tempered by a limited level of investment. There are significant positives in relation to teacher attitude and legacy resources from past ICT initiatives. However, confidence in the quality of schools' technology and a consequent favourable disposition towards ICT usage among teachers has been dented due to lack of follow-on programmes and consistent funding. Ireland should be at the leading edge of EU educational and technological developments. While our situation is not unique, it needs to be reconciled with stated Government intentions in this regard.**

Figure 39 - Investing Effectively, p.6.

This summary hardly relates to what has preceded it. Decisions by persons not qualified to make them have greatly contributed to the failures outlined in the EC/Empirica report and in the Ireland ranking comment by Minister Hanafin – they are not all down to funding deficits.

Section 2.3, headed *Infrastructure, Technology and Innovation*, starts very authoritatively by seeming to quote the almighty OECD: 'A lack of sustained investment in ICT infrastructure has resulted in Irish schools falling far behind their European peers (OECD, 2007).' This is a reference to the OECD's 451 page publication, *Education at a Glance 2007*.

Well, at a glance, annual expenditure on educational institutions per student in primary through tertiary education (2004) shows Ireland to be about midway in spend, which is remarkable given its economic difficulties in previous years.

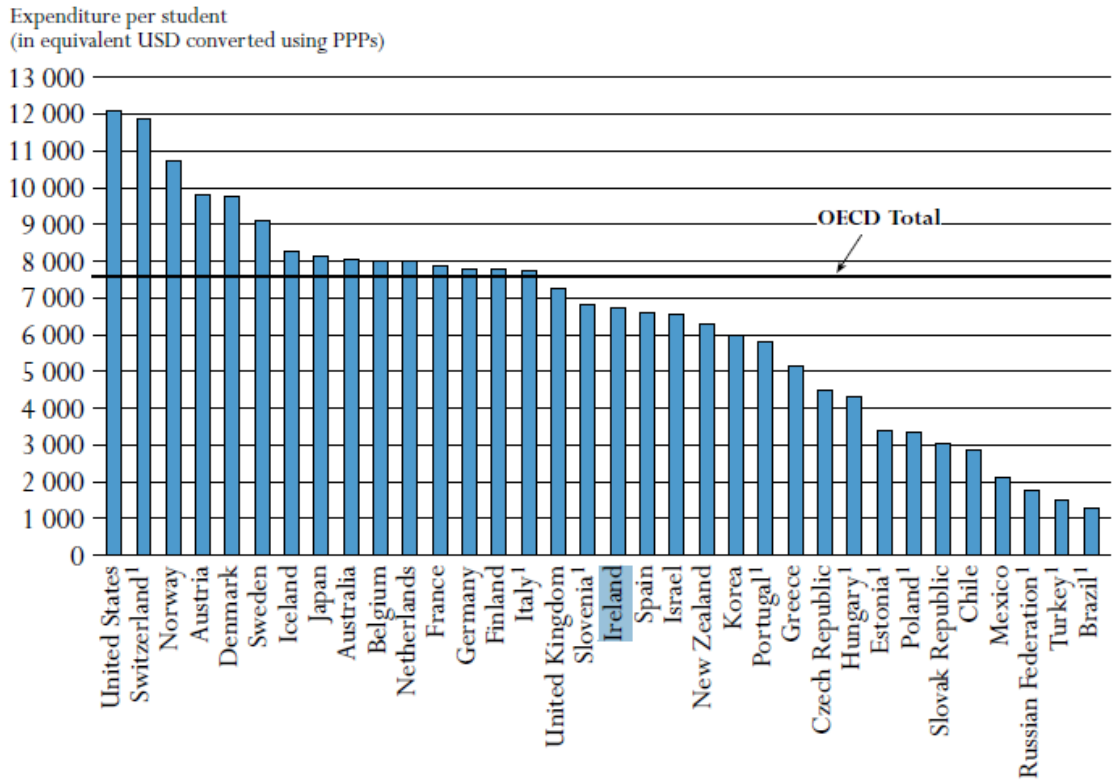

Figure 40 - OECD, Education at a Glance, p.170.

For primary education, which is the main focus of this paper, the OECD paper shows that Ireland is once more midway in spend, close to the OECD average:

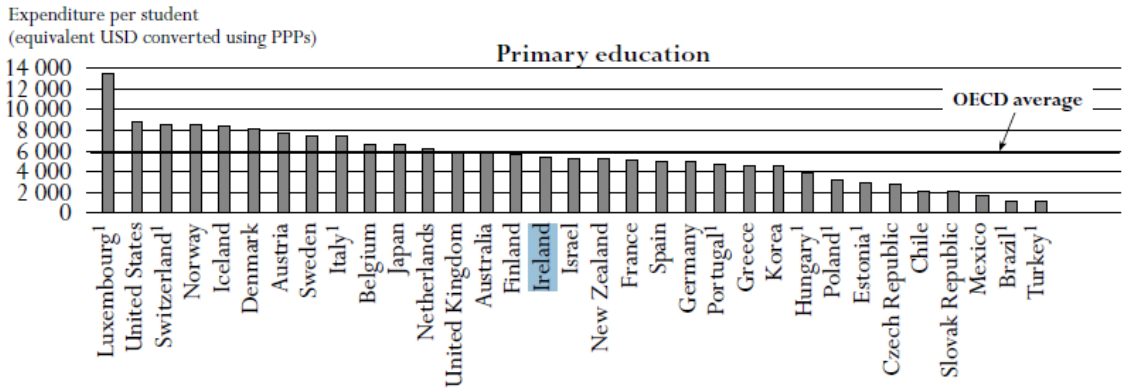

Figure 41 - OECD, Education at a Glance, p.173.

In fact, the report points out that 'in Ireland, the strong growth of GDP hides a significant increase in spending on educational institutions when spending on education is considered as a proportion of GDP (OECD, 2007, p.202).' It may very well be that more investment is desirable in everything from health to policing and

education, but to endeavour to blame Ireland's ICT woes and declining teacher enthusiasm for ICT on funding alone is not telling the whole truth.

7.5 Broadband Inadequate for Schools

Finally, *Investing Effectively in Information and Communications Technology in Schools, 2008-2013* grasps the nettle and utters the horrible reality:

> 'However, it has become evident that the level of broadband-delivered internet is *inadequate to meet the needs of schools*, with insufficient bandwidth and high contention ratios *making multiuser access impractical generally and impossible in some cases.* While the issue of broadband quality and availability in schools *is a consequence of the fragmented nature of the national broadband infrastructure*, the lack of sufficient bandwidth in schools is a primary barrier to teachers and students using online digital resources in the daily life of the school (DESb, 2008, p.8).'

It is only so because those in charge made it so – it did not come about by accident. Persons whose hands so recently baked the pie on the plate should now step up to the plate and take responsibility, but will the summary section below this part – aimed at busy movers, shakers and decision makers who don't have time to read full reports – will it recall and accurately reflect the *mea culpa* just expressed?

In brief: there has been markedly successful ICT-related education change in many schools as a result of Government ICT investment programmes. But this progress has not been system-wide and frequently lacked depth and resilience in the absence of recurrent development and financial support. There is a need to find ways to deal more effectively with ICT-facilitated change and the challenges it brings. There is also a need to foster innovative thinking and to invest in scaling up from pilot settings to more mainstream implementation.

Figure 42 - Investing Effectively, p.8.

It is difficult once again to relate the summary to its original, a sign that many of the decision makers dealing with ICT in Irish schools are unwilling to face facts. Perhaps

it's time for a change of personnel, as was suggested very recently in the banking sector following the banking crisis.

7.6 NCTE Failure

Section 3, *The Future*, reads like a partial reprint of the NCTE Annual Report for 2002. Just as a previous reference in this study noted: 'The Annual Report for 2002, which followed the publication of *The Blueprint for the Future of ICT in Irish Education*, suddenly targets the 'key role of the school principal in leading ICT in schools' and ICT planning 'at school level'. Busy principals were suddenly handed 'a methodology and a resource pack to enable them to assess their needs and to specify the technology needed to address those needs'. Now unskilled, inexperienced and busy principals were told to go it alone with a resource pack and one or two briefings', once more school principals are hailed as the leaders upon whom *Creating leading-edge e-learning environments* depends: 'Every school, under the leadership of the principal and supported by the ICT coordinating teacher, must strive towards effective whole-school ICT coordination' – a line that is repeated in different guises for eight succeeding paragraphs. School Leaders must do nearly everything, regardless of their own ICT ability, qualifications or interest in the subject – they must recognise ICT as a key enabler, must look after everyone's CPD needs, must avail of supports in the NCTE and in their local communities 'and beyond'... must create a whole-school shared vision, form a School ICT Committee now as well to plan and guide ICT integration at local level, must consult widely...

This 6 year old attempt to once more foist responsibility on local school principals and as yet unformed ICT committees consisting of non-IT professionals is nothing less than a renunciation of responsibility for taking charge centrally, at the top, for taking a strong lead, for setting out requirements agreed by IT network and technology industry professionals, for taking centralised action to right the Olson Imaginary Restaurants' mess... It is a disgraceful admission of failure by the body charged to take precisely that responsibility over the years, and financed to do so, namely the NCTE and its appointed ICT Advisors working out of the local Education Centres and with high-level access to industry and third-level professional partners.

The Future is mapped in a learner-centred half-maze:

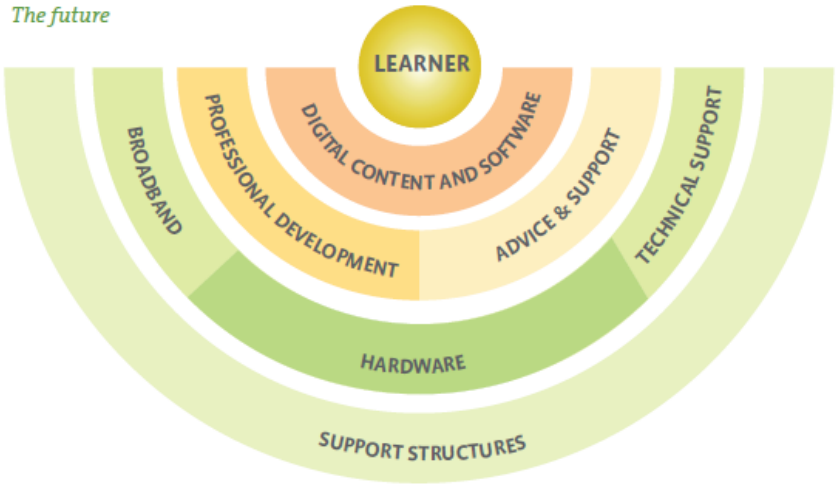

Figure 43 - Investing Effectively, p.14.

In a temporary return to the forthright tone, the third line, Broadband, Hardware and Technical Support, is finally declared to be foremost among the essential critical success factors: 'The provision of ICT infrastructure including broadband, technical support and school networking which is reliable, available where needed, easy to use and sustainable (DESb, 2008, p.14).' This study entirely endorses that statement because until broadband connectivity to the cloudy HEAnet Schools' Network is equalised and modernised across the country – in the opinion of this study, by fibre connectivity – ICT is stalled in very many schools outside major cities, as former Minister Hanafin admitted.

The more in-depth discussion of hardware occurs in Section 4.3 *ICT equipment – additional and replacement*. Here the discussion emphasises that principals and teachers 'have called for a more centralised approach to procurement and pricing structures to ensure that they get the best value for money (DESb, 2008, p.21)'; it further notes that standardisation of ICT across organisations facilitates easier, simpler and more uniform and cost effective technical support options and that the prior free-for-all in ICT purchasing has created a complex support problem that will be very expensive to address. The reader might therefore expect that the report would call for standardisation of ICT in schools and a centralised purchasing option for all schools to

create that value for money procurement and associated uniform technical configurations and support elements.

But no, the report continues to vacillate on these points – schools may take advice from the NCTE and others but should still retain 'a level of autonomy and choice in their final purchasing decisions by issuing mini-tenders individually or in local school clusters (DESb, 2008, p.21)' and – in relation to technical support – why, ensure that every purchase comes with a three-year warranty! How does purchasing three-year warranties on new hardware support older hardware in the school LANs? 'Suitable ICT purchase configurations will be determined by each school (DESb, 2008, p.21).'

This is not so much a strategy as an absence of strategy, a lack of policy to get individual schools to somehow create out of some scraps of advice an ICT structure that will magically fit into a broader scheme as yet not the responsibility of any named party. It's a lotto strategy for schools - gamble and you've a chance of getting it right.

7.7 NCTE Without Strategy

Section 4.4 *Schools Broadband Services* announces the objective to 'ensure that every school has access to an appropriately specified, cost-efficient broadband service that is delivered to all learning areas within the school (DESb, 2008, p.22)' and then declares that it cannot see how the €252 million National Development Plan allocation will stretch to making that broadband available since there are so many schools. Instead, it calls for efforts to ensure that the broadband that is not currently available should nevertheless be able to have access to all parts of the schools in future. Meanwhile, it suggests that the Government should regard broadband access as part and parcel of national infrastructure and should therefore cough up to somehow deal with the consequences of the earlier decision to go with useless satellite broadband which is now tied to 47% of schools who can't get any traction out of it owing to the predicted latency and contention. And in the meantime, establish another expert advisory group to advise the NCTE on broadband developments – two pages later, it calls for the establishment of a consultative and representative forum for

education and industry partners to advise the NCTE on ICT in education - the NCTE wants so many advisory groups that it would be cost beneficial to join them together to form an expert grouping and delete the non-expert NCTE entirely.

The report authors do not ever join the dots – the recommendations continue in a fragmented manner: design a national tender for broadband provision so that migration to better bandwidth is automatically implemented during the lifetime of the granted agreement; give schools the option to purchase their own additional bandwidth; ensure migration from satellite to other services such as DSL; make available to schools centralised broadband services such as data and Web site hosting and VLEs (virtual learning environments); improve the current broadband.

Similar fragmented arguments occur in *Section 4.5 Technical Support & Maintenance* where the primary factor that makes centralised technical support a non-runner is downplayed – the series of disastrous decisions to allow all schools to spend ICT money as they saw fit locally during the past decade without any centralised requirements such that now there are so many different systems in place that it's a seriously big mess.

'Assuming greater homogeneity in the future' the prayer of the faithful continues – how could there possibly be greater homogeneity in the future when the 'strategy group' has earlier recommended schools should be allowed to spend money as they see fit, that individual principals become local ICT leaders on their own, aided by as yet unformed school ICT committees of educators and supported by community involvement and ideas from 'beyond'? Assuming greater homogeneity in the future, let us have a centralised service that can handle 4,051 (2007) schools dispersed across Ireland all running different hardware, software and broadband services on differently ageing systems and let us tack it onto the NCTE Broadband Service Desk so that the NCTE continues to oversee, disastrously, the mess it has helped to create since 1998.

And having just recommended a centralised service and a cost benefit analysis of same and a pilot programme, sure why not also recommend something related but entirely opposed – investigate the feasibility and practicality of a VEC support scheme for schools in their areas – this alongside the centralised, piloted, costed

service just recommended... And let's add a firm recommendation that any computer over 6 years old – and there are lots of them – should be denied technical support and so the Special Needs teacher still running tried, tested legacy software on the Windows 98 machine for her special needs students should be left high and dry and let no-one tell her that she may possibly be able to run the software in Compatibility Mode on all versions of Windows since Windows XP... Some prayers of the dithering were never meant to be answered.

7.8 Absurd Recommendations

The absurdity of the strategy group's recommendations with regard to technical support and maintenance is nowhere more evident than in the recommendation to install a technical support server in every school – that's 4,051 new servers doing nothing but take up vital space, bandwidth, electricity, maintenance, and money alongside the LAN servers already in place - to allow for remote log in and diagnosis of the school LAN, and tack on a recommendation that each new underused server might act as – somebody mentioned – 'a proxy server for digital content'. Two modern and critically unavoidable words are entirely missing from the Strategy Group report – one is 'cloud' and the other is 'virtualization' and we shall deal with these shortly.

It was never more clear that this Strategy Group was itself in dire need of technical support and maintenance and recommendations from industry professionals before delivering such wrong-headed and wasteful advice to the Minister. The under-utilised servers (under-utilised owing to inadequate broadband, among other reasons) already in place on the school LANs can easily support remote log in and diagnosis. (To be fair to the Strategy Group, in the section that follows, 4.9 *Allocation of funding and overall budget*, the group amends the call for servers for every school only to schools with over 300 pupils based on criteria that are not explained.)

It is impossible for organisations to speak authoritatively and to lead vigorously and intelligently – and to expect people to follow – when those claiming to lead are asking for advisory committees on the deployment of broadband to schools and on the implementation of ICT in schools after over a decade in the game. If organisations

need that kind of advice and slow, moribund committee reporting after so many years, they either lack the vision, energy and expert personnel to do the job, or else they never had the vision, energy and expertise to do it and were no more than followers.

What other kind of leadership is there? There is, for instance, the Obama style of leadership regarding technology and broadband in schools, to which we now turn for a shot of charismatic energy, clear direction and vigorous faith. The personnel President Obama chooses to lead on his behalf have already earned the respect and admiration of their peers.

7.9 Conclusion

This chapter recounted the lamentable failures of the unqualified NCTE to lead or manage ICT over a decade and its resort to seeking yet more expert advisory groups and to dumping ICT responsibility on individual school principals. The lesson of a decade is perhaps that educators should stick to education and let qualified ICT personnel work on ICT long-term planning and integration.

8 Obama-style Broadband for Schools

> 'My economic recovery plan will launch the most sweeping effort to modernize and upgrade school buildings that this country has ever seen. We will repair broken schools, make them energy-efficient, and put new computers in our classrooms. Because to help our children compete in a 21st century economy, we need to send them to 21st century schools. As we renew our schools and highways, we'll also renew our information superhighway. It is unacceptable that the United States ranks 15th in the world in broadband adoption. Here, in the country that invented the Internet, every child should have the chance to get online, and they'll get that chance when I'm President – because that's how we'll strengthen America's competitiveness in the world.'
>
> *Remarks of President-elect Barack Obama Radio Address on the Economy Saturday, December 6, 2008* (On YouTube here.)

8.1 Introduction

This chapter shows how great leadership allied to knowledge of the latest technological advances can face up to the construction of new models of learning and new attitudes to the requirement for fast fibre connectivity for schools to exploit the advantages of virtualization and cloud computing not only for schools, but also for entire communities surrounding them.

8.2 Outstanding Leadership

In March 3rd, 2010, the US Secretary of Education, Arne Duncan, spoke about the imminent publication of a new document entitled, *Transforming American Education: Learning Powered by Technology* which was a draft version of the National Educational Technology Plan 2010 (NETP).

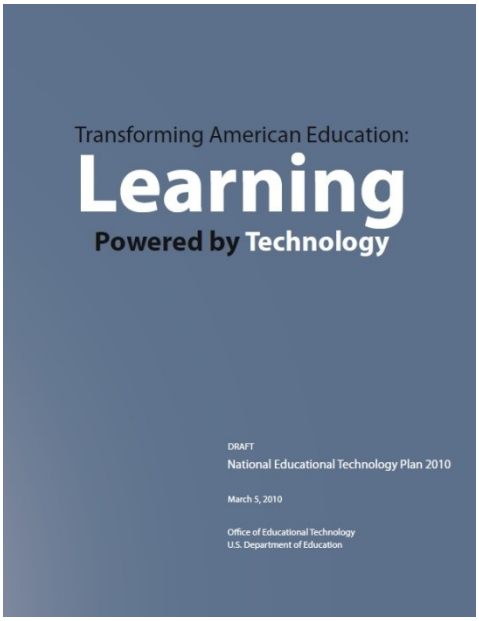

Figure 44 - Obama Plan

Mr Duncan, son of a professor at the University of Chicago and a mother who ran a South Side tutoring program for inner-city children since 1961, had earned the right to be Secretary of Education and to announce such a futuristic and revolutionary document. His biography reveals outstanding qualities of leadership and experience evident to all. He was for 7 years Chief Executive Officer of Chicago Public Schools during which time he instituted an aggressive education reform agenda, opened over 100 new schools, expanded after-school and summer learning programs, closed down underperforming schools, increased early childhood and college access, dramatically boosted the calibre of teachers, and built a series of public-private partnerships. Under Duncan's leadership, an all-time high of 66.7 percent of the district's elementary school students met or exceeded state reading standards, math scores also reached a record high, with 70.6 percent meeting or exceeding the state's standards. At high schools, Chicago Public

School students posted gains on the American College Testing Program at three times the rate of national gains and nearly twice that of the state. The number of high school students taking Advanced Placement courses tripled and the number of students passing AP classes more than doubled. Duncan increased graduation rates and boosted the total number of college scholarships secured by CPS students to $157 million. While he was in charge between 2001 and 2008, the number of teachers applying for positions almost tripled from about 8,600 to more than 21,000, or about 10 applicants per teaching position (USDE, Senior Staff Bios).

In a personal life whose wide accomplishments are difficult to encompass, he graduated magna cum laude from Harvard University, majoring in sociology, was co-captain of Harvard's basketball team and was named a first team Academic All-American. He credited basketball with his team-oriented and highly disciplined work ethic. Secretary Arne played professional basketball in Australia from 1987 to 1991, where he also worked with children who were wards of the state. He ran the Ariel Education Initiative (a non-profit education foundation which helped fund college education for a class of inner-city children under the *I Have A Dream* program), Chicago Cares, the Children's Center, the Golden Apple Foundation, the Illinois Council Against Handgun Violence, Jobs for America's Graduates, Junior Achievement, the Dean's Advisory Board of the Kellogg School of Management, the National Association of Basketball Coaches' Foundation, Renaissance Schools Fund, Scholarship Chicago and the South Side YMCA. He also served on the Board of Overseers for Harvard College and the Visiting Committees for Harvard University's Graduate School of Education and the University of Chicago's School of Social Service Administration (USDE, Senior Staff Bios).

In announcing the draft publication *Transforming American Education: Learning Powered by Technology* this attested leader quoted the President's Chief of Staff, Rahm Emanuel: 'You should never waste a good crisis'. The NETP was intended to make schools 'centers of learning designed to close the gap between the technology-rich and exciting experiences that dominate students' lives *outside of school* while preparing them for success in today's competitive global marketplace'. This was a recognition that schools were lagging behind the learning curve of students outside the schools where the always-on Internet fed information 24/7/365 across a multitude

of fixed and mobile devices. Learning was transcending school hours and becoming life-long while schools were disconnected. Crises can sometimes energise societies to grasp fundamental change and new technologies.

In his speech Duncan said, in brief:

- Schools and their content must keep pace with the 21st Century.
- Students must be fully engaged by relevant, interesting projects through technology allied to online learning environments.
- Educators must engage with technology tools and *collaborate in learning* with their students.
- Students can't remember a time without the Internet.
- Relevant on-demand technology learning tools that are part of their daily lives outside must be used by schools to bridge the widening gap.
- The key technology trends are always-on accessible mobile learning devices allied to digital content often produced online by students themselves.
- Educators must harness online social networks for information, collaboration and learning.

There were five goals to the draft technology plan:

- Learning
- Assessment
- Teaching
- Infrastructure
- Productivity

Technology can personalize learning and increase relevance and opportunity to achieve, also for those disadvantaged or with disabilities. Data from technology-based assessments can diagnose students' strengths and weaknesses and allow for immediate performance-enhancing feedback and improvement across the system. Technology can connect teachers to tools, resources, experts and peers and support their own growth, effectiveness and development, while making them feel supported

across various networks, avoiding any sense of isolation. Infrastructure is '*broadband connectivity for all students, everywhere—in schools, throughout the community, and in students' homes, and we look forward to the release of the FCC Broadband Plan to support this effort*.' Technology can help to deliver productivity in the learning process and it can provide more accurate views of that and of financial performance for decision makers (USDE, Speech).

Many inner city and rural populations were disadvantaged and poor and the growing digital divide must be overcome to give every citizen equal opportunities, equal digital citizenship.

8.3 Learning Powered by Technology

Almost as a throwback to 50 years ago and longer, education today can still take the form of a 'rigid information transfer model' - information flow from teacher and book to student in one classroom, and can be heavily influenced by a singular relationship between teacher and students. Outside school, many students' lives are filled with technology devices that give them 24hr anywhere access to instantly searchable global learning materials, along with unlimited social collaboration around learning, and the ability to create and publish multimedia content on the Internet in minutes as authors.

Learning in Informal and Formal Environments (LIFE) is captured in the following diagram taken from the US National Science Foundation Science of Learning Center showing in two colours the relative percentage of their waking hours that people spend in formal educational environments versus the much greater periods of informal learning situations across their lifespan.

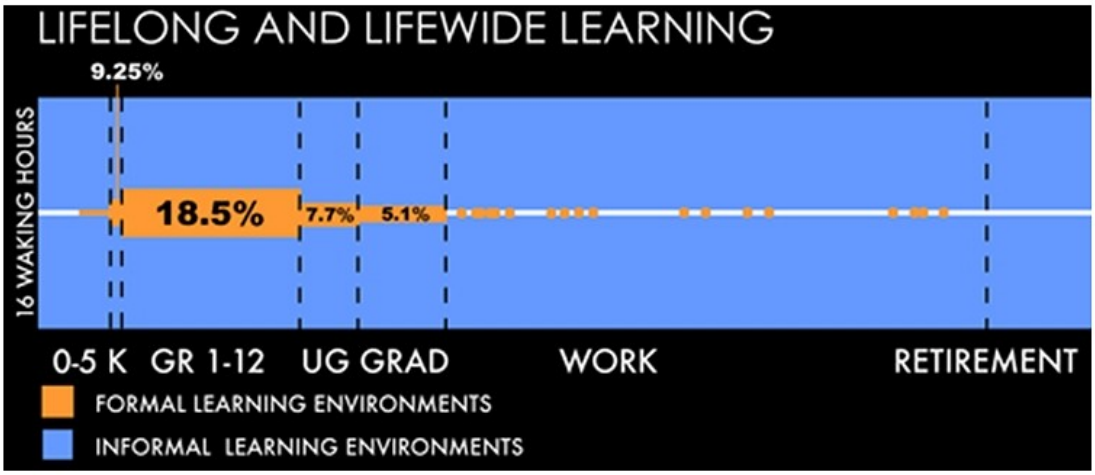

Figure 45 - Lifelong and Lifewide Learning (LifeCenter)

According to a national survey by the Kaiser Family Foundation, 8 to 18-year-olds today devote an average of 7 hours and 38 minutes to using entertainment media in a typical day – more than 53 hours a week (Kaiser Family Foundation, 2009). Gaming and use of avatars greatly attract young learners and so should inform educational programming and teaching tools.

New learning takes account of the fact that many students will have many jobs in their lifetimes, unlike their parents or grandparents, and will need to grasp life-long learning, to know or be able to find out new answers in their work using the Internet, as many medical and scientific personnel routinely do already. Learning has become seamlessly welded to the technology that facilitates it.

Clearly the traditional model of learning has been infinitely and irrevocably impacted by technology and now schools must compete and leverage that technology in proven ways to engage students of today and citizens of tomorrow, aware though that learning has escaped the confines of school alone for ever.

The new choice-filled collaborative technology driven model of learning is indicated in the figure below catering for group, small group and individual personalized forms of learning from a wide range of sources and experiences.

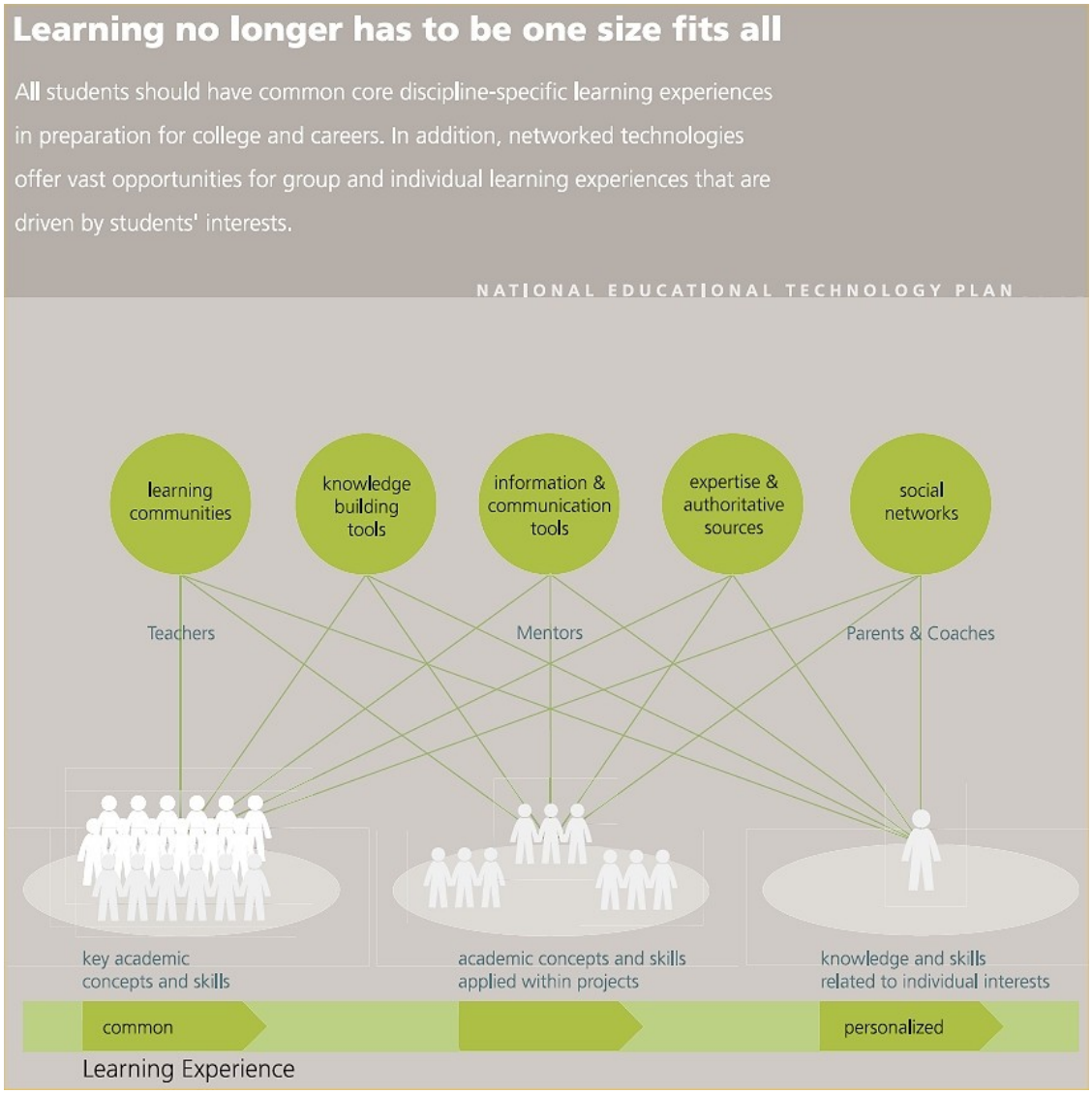

Figure 46 - USDE, Learning Powered by Technology, p.11.

8.4 High Speed Broadband a Prerequisite

However, the technology-driven new model of learning is entirely dependent on the provision of high-speed broadband to those many citizens across America (and the world) who don't have high-speed broadband access owing either to poverty or disadvantage or else owing to location in rural areas far from broadband providers. Slow-speed broadband access isn't cutting it. Schools in these areas, and libraries which would normally try to provide free Internet access, are targets for broadband connectivity – or else faster broadband - in various schemes under the umbrella of The American Recovery and Reinvestment Act of 2009 (ARRA) which are intended to accelerate penetration of Internet services in unserved and rural areas and to

strategic institutions that are likely to create jobs or provide significant public benefits, such as hospitals that might use telemedicine or emergency services – fire, earthquake, meteorological, national guard – that might definitely benefit by means of communication and research.

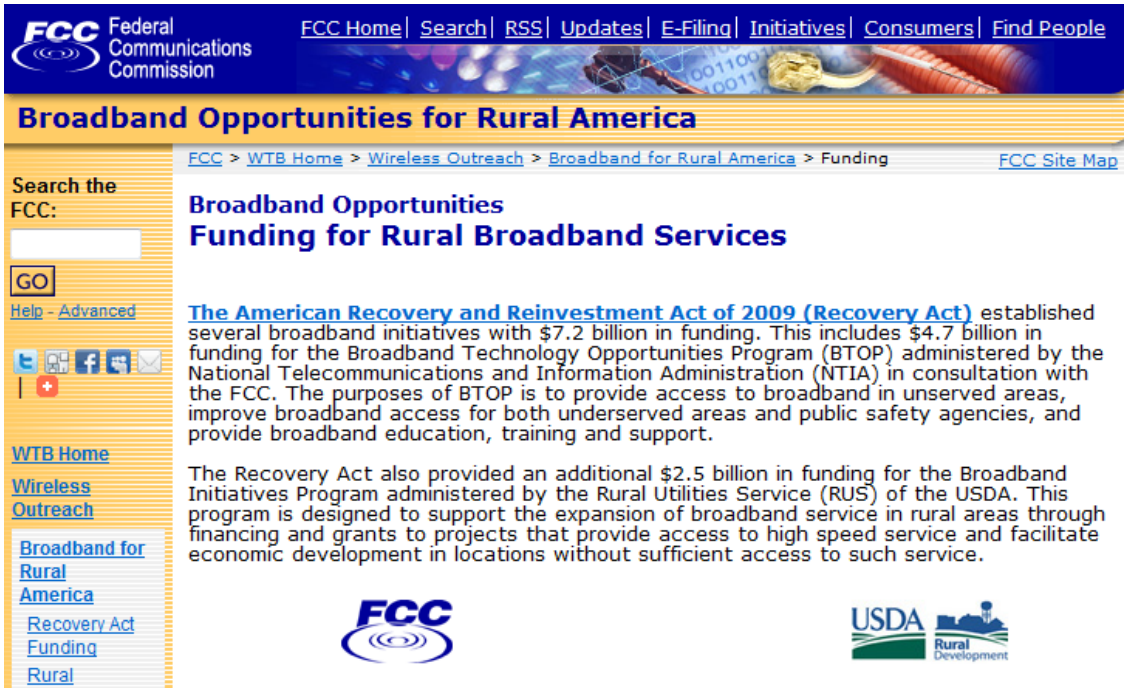

Figure 47 - US Broadband Funding Rural Areas

The catch-up provision programs include the Broadband Technology Opportunities Program (BTOP) of the Department of Commerce's National Telecommunications and Information Administration (NTIA), the Rural Development Broadband Program (BOTP) of the Department of Agriculture's USDA Rural Utility Services (RUS), and a trans-agency National Broadband Plan that is being developed by the Federal Communications Commission (FCC). While the total of $7.2 billion may seem a lot in Irish terms, it has to be spread across a vast continent of many different terrains to very many destinations.

The particular Schools & Libraries program allows these institutions, whether in urban or rural disadvantage, to apply for between 20% and 90% of the cost of gaining broadband connectivity. The American Library Association (ALA) says that many libraries are already connected to the Internet, but they mean in the manner that the NCTE used to say 99.9% of Irish schools were connected to the Internet - the libraries

are bedevilled by the same nuisance affecting those same Irish schools – bandwidth: 'Although the need for libraries to provide broadband access is increasing, many libraries are ill-equipped to meet this need. In 2006, 98 percent of public libraries indicated that they provided public access to the Internet, but in the same survey, 45 percent reported that they did not have sufficient bandwidth to satisfy their community's needs. Libraries without enough bandwidth to quickly transfer data, images, and video put their communities at a serious disadvantage (ALA, 2010).'

It's the same old story, previously provisioned connectivity that is useless and the money that went into it in the first place is entirely wasted before the 'migration to better speed' money is spent on top of it. Why not do it once and get it right? The American Communication Workers Union, which lobbies on behalf of libraries, operates a www.SpeedMatters.org Web site to highlight its principles for a national high-speed Internet policy which include:

- Universal access to affordable broadband as a matter of civic equality and digital literacy.
- High-speed broadband – 'Speed matters on the Internet. U.S policies should promote higher Internet speeds and higher capacity networks. The U.S. should adopt policies to get us to 10 megabits per second downstream, 1 megabit per second upstream by 2010, with new benchmarks for succeeding years (CWU, 2009).'

When American Web site viewers take the broadband speed test on the www.SpeedMatters.org home page, they get not only the speed of their connection at that particular time, but an international comparison to stir their ire:

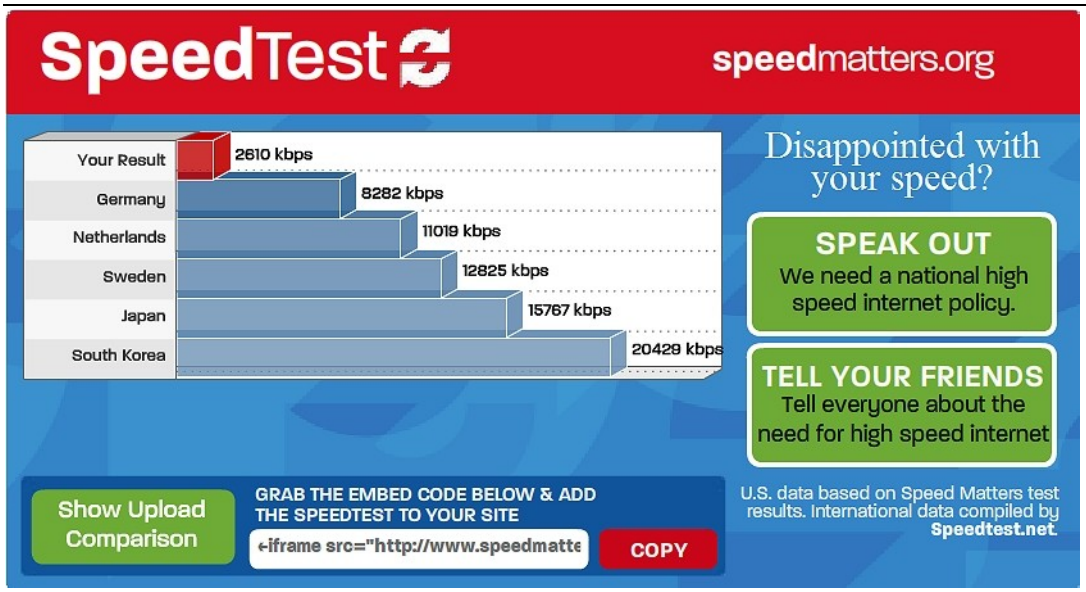

Figure 48 - Speed Test Comparison - www.SpeedMatters.org

Is any of this lobbying and Obama-style action bringing about change on the ground? On February 18th 2010, the Wisconsin State Superintendent Tony Evers issued a press release thanking President Obama and ARRA for a grant of $22.9 million toward not just broadband connectivity, but fibre connectivity. The state of Wisconsin was adding another $5.7 million to that figure to make a grand total of $28.7 million:

> ‘’This funding will bring fiber optic connectivity to schools and libraries in rural areas that do not have this vital Internet service, which has almost unlimited capacity to carry Web-based services and other applications. Additionally, the grant will provide high-speed Internet access to 74 school districts; eight postsecondary institutions, including two tribal colleges; and 385 public libraries; connecting them to the BadgerNet Converged Network. Bringing fiber to these sites in predominantly rural areas also will create the opportunity for affordable broadband access to residential and business customers in the entire community. Internet access is an essential service. In many communities, the library is the only free public access available for those seeking to improve their lives, look for work, or start a business. This grant is wonderful news for Wisconsin’s schools and libraries (Press Release).”

Can we in Ireland do this? **Yes we can**.

8.5 Fibre Leads to Regeneration

Evers links the provision of fibre connectivity to schools and libraries in rural areas to a method of also connecting communities that otherwise would not get fibre broadband. In fact, the program of grants for fibre connection takes in not only the schools and libraries, but also nearby communities, fire and emergency services, hospitals, researchers providing real-time data about earthquakes, storms and floods and – last but not least – thousands of jobs immediately for the telecom and construction sectors and, as a result of a skills' base grown by fast broadband, more jobs into the future as Internet savvy graduates enter the job market. It's a total regeneration package for rural areas.

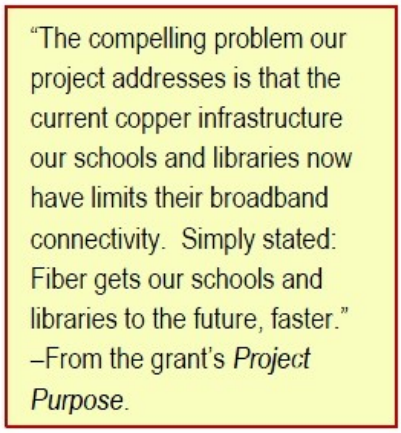

Figure 49 - Copper Denied

It is not the intention to deal here with all of the rich and informative 98 pages of *Transforming American Education: Learning Powered by Technology*, even though that would be an entirely rewarding study, but instead to look closely at the *Infrastructure: People, Processes and Technologies for Learning* section beginning on page 51. At the heart of Obama's regeneration policy for schools is a particular type of technology recommendation to which we now turn. Obama's package is not just about provision of high-speed fibre connectivity to schools, libraries and disconnected, disadvantaged communities – it's not speed alone that he is seeking, but full bang for every buck spent, so his policy is unashamedly about something allied to or built upon speed that he and his advisors feel will increase services and at the same time save money – and that something is Cloud Computing.

The report tells us that its model of education has two overarching influences. The first is the National Science Foundation's concept of 'cyberinfrastructure' firstly envisioned for collaboration between scientists and later widened to apply to all forms of education. The term joins two unavoidable realities of modernity – 'cyber' referring to the collapse of obstacles of space and time to learning in the physical

world – and 'infrastructure' which admits – entirely in line with the thrust of this study – that 'even in virtual worlds, physical and organizational structures are needed to run a system (NSF, 2008, p.51)'.

Under the heading 'Broadband Everywhere' the report pulls no punches, 'A crucial element of an infrastructure for learning is a broadband network of adequate performance and reach, including abundant wireless coverage in and out of school buildings. Adequate means *enough bandwidth to support simultaneous use by all students and educators anywhere in the building and the surrounding campus to routinely use the web, multimedia, and collaboration software* (NSF, 2008, p.53)'.

8.6 Benefits of Virtualization

As a first step, adequate bandwidth must be allied to the architecture of next generation computing which has already proven itself in business in terms of vast savings on hardware and software via virtualization.

Since the modern advent of both personal and business computing on a vast global scale, the costs associated with buying and maintaining the hardware and hugely expensive software licenses of millions of under-utilized servers, not forgetting electricity costs in running and cooling them, have created a lucrative market for virtualization. The phrase 'under-utilized servers' refers to the fact that most servers are only running at maximum 10%-15% of their capacity, and in fact many at only 5%. Remember also that many servers have little workload after 5pm and at weekends, but they must still be run and cooled; also many servers exist solely as standby machines in case of disaster or breakdown of their fellows, but are never actually called upon at all. This adds up to massive avoidable costs.

To take a very small but comprehensible example, imagine the cost of running five decentralized servers with all the associated hardware purchase of cabling, switches, labour, maintenance, licensing costs, electricity, cooling and space and spare parts:

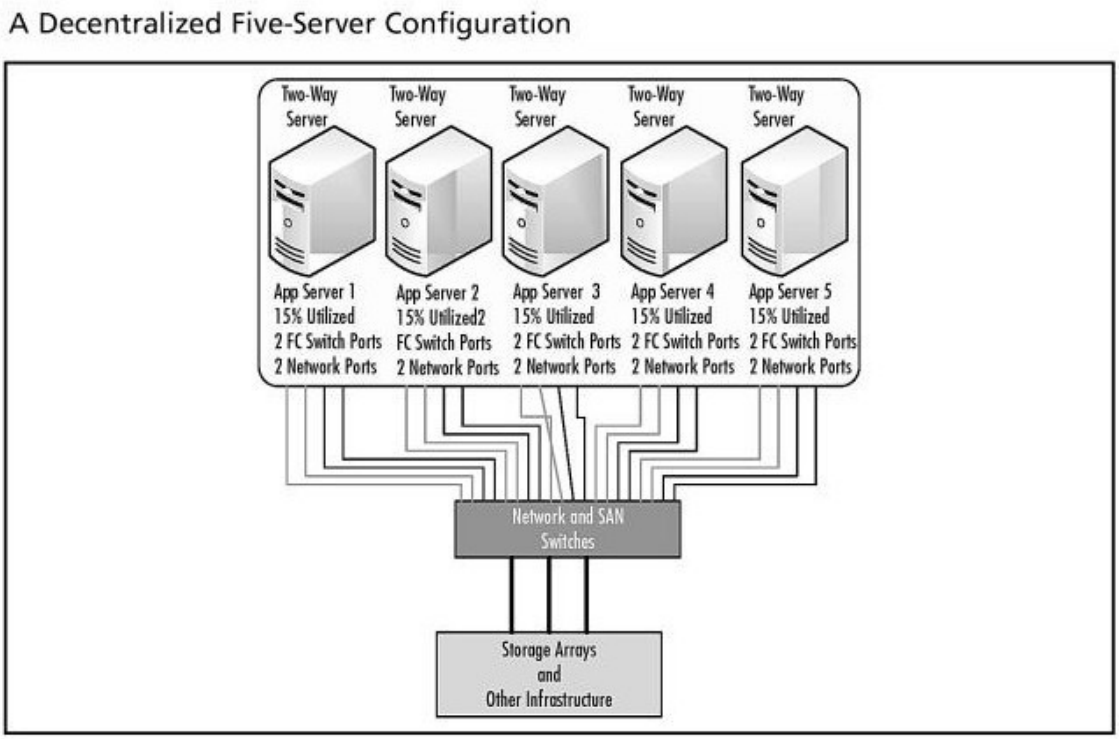

Figure 50 - Five Decentralized Servers (Rogier & Dittner, 2007, p.9).

Virtualization would transform the five decentralized servers into one physical server running five virtual servers, thereby also increasing the utilization of the server to around 75%:

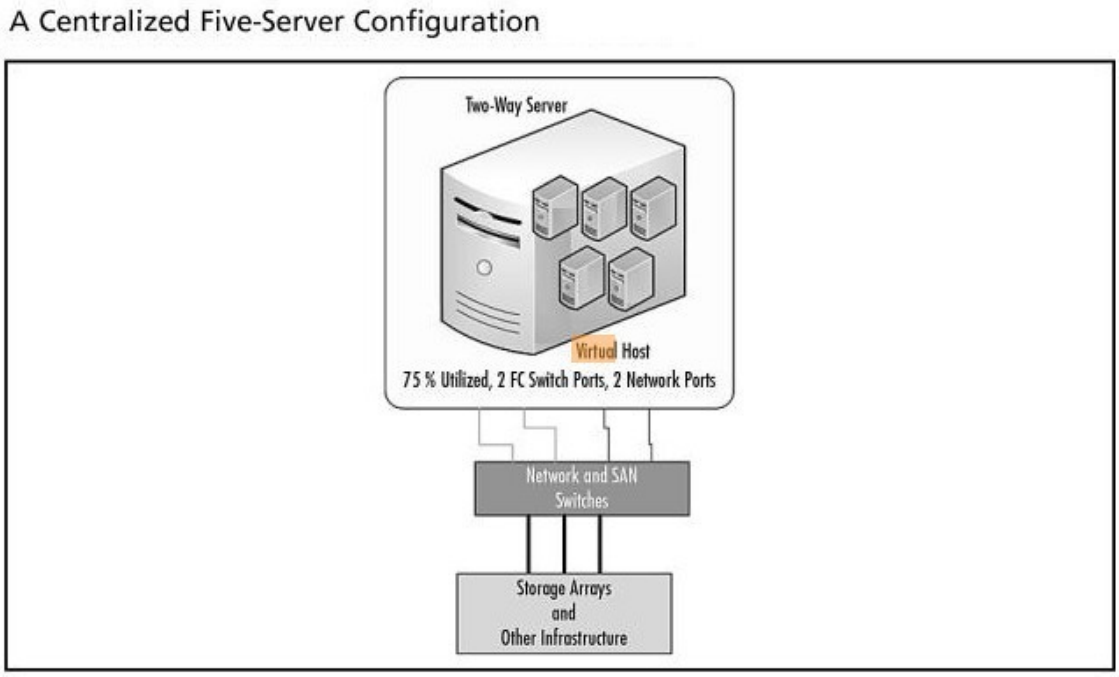

Figure 51 - Centralized and Virtualized Servers (Rogier & Dittner, 2007, p.10).

The actual cash cost comparison and savings are evident in the table below:

Component	Unit Cost	Physical Cost	Virtual Cost
Server hardware	$7,500.00	$37,500.00	$7,500.00
Software licenses/CPU	$2,000.00	$20,000.00	$4,000.00
Supporting infrastructure	$2,500.00	$12,500.00	$2,500.00
Power per server year	$180.00	$2,700.00	$540.00
Cooling per server year	$150.00	$2,250.00	$450.00
Total three-year costs:		$74,950.00	$16,490.00
Realized savings over three years:	**$58,460.00**		

Figure 52 - Cost Comparison and Savings (Rogier & Dittner, 2007, p.9).

Following the initial breakthrough products such as VMware and Xen, many companies are offering software products to produce virtualization on this and even on greater scales. But the report only recommends this as a first step – in this example, the school is still paying for and running a server configuration, or datacentre, with a lot of associated computers and hardware and software costs.

8.7 Cloud Computing Recommended

The report continues that beyond mere server consolidation many schools are moving to the second overarching influence - cloud computing - which has a number of immediate savings: schools can delete the local server configuration entirely and all associated costs and they can go forward providing nothing more than the thinnest clients or else run all their ageing computers as thin clients connected to Software as a Service offerings and Web applications from datacentres running in the cloud as Pike County has done, as mentioned earlier.

In fact, the report argues, the schools may achieve one of the holy grails of computing – utility computing - the purchase of computing as a metered service much like electricity is sold. Olson's imaginary freelance restaurants are at last vanquished by science, technology and intelligence working together. No longer does each school have to replicate the horrible meccano of hardware potholes across entire counties and provinces with all their avoidable costs and environmental impact. Move the

datacentre and software applications to the cloud and walk away with worries only about provision of Web browsers to staff and students. Cloud computing is always on so serves both in-school and out-of-school learning; it can support school administration 24/7 as well. Cloud computing can deliver the following 21st century comprehensive and integrated services more cheaply and more efficiently:

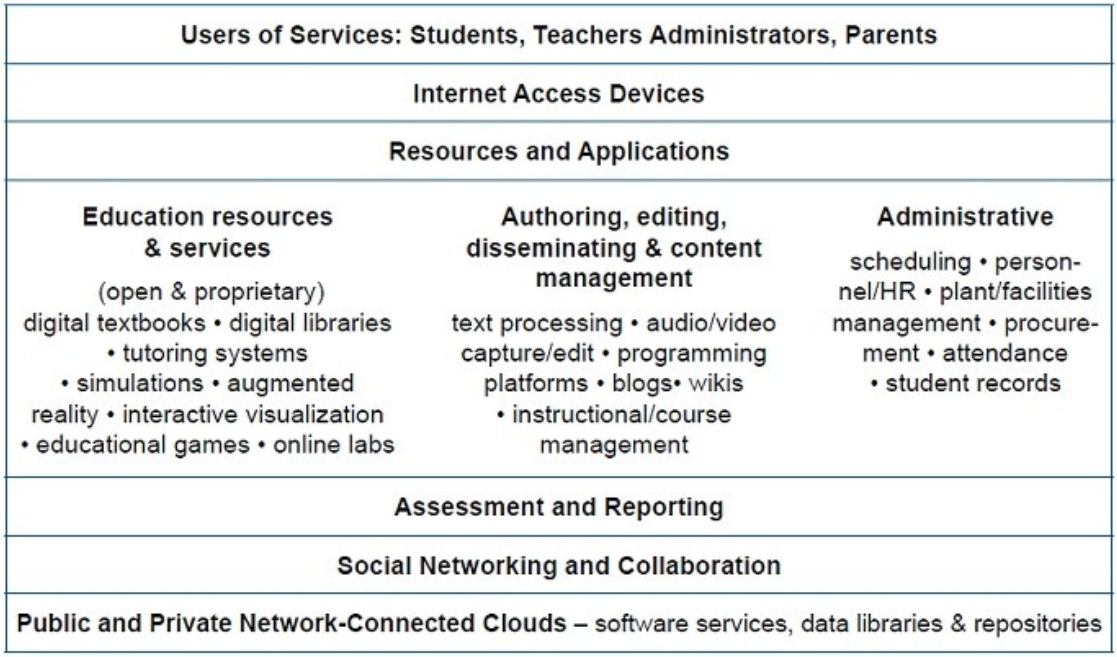

Figure 53 - USDE, Learning Powered by Technology, p.58.

Many SaaS offerings are entirely free of any charge anyway thanks to competition between Microsoft and Google and others. Schools don't have to pay a cent for every student to have a free email address, free online storage of documents, free Skype accounts, free video storage and delivery, free photograph storage and delivery, etc.

However, Obama is not just providing fast fibre connectivity to schools, but is calling on them to modernize attitudes to learning and to computing, whether to cloud computing or to engaging with students' mobile devices. But investment is better spent on getting it right once instead of revisiting the problem with waves of new money to overcome repeated poorly scaled provision and planning. So go for fibre.

8.8 Conclusion

This chapter highlighted how a more imaginative, more brilliant and equally economically challenged administration can face new technology and its consequences for old models of learning. Radical solutions are applied to radical problems. Fast fibre connectivity for all – as in the Wisconsin example - and the clinching of virtualization and cloud computing for their undoubted cost savings and centralized advantages. This model is free for imitation.

9 Ireland and The Smart Economy

9.1 Introduction

By contrast with the Obama style of leadership, with plenty of substance, the Irish Taoiseach's ability to mouth the jargon of 'smart economy' and 'next generation broadband' is nothing more than empty rhetoric. Stupidly quoting the ridiculously inexpert Strategy Group report, the Irish government's plans are lacklustre whether evidenced by the National Broadband Scheme of non-fast-fibre connectivity by 3 or by its implementation of a further digital divide in schools. Three saving voices finally combine - the Knowledge Strategy report, Forfás and ComReg – to at last demand for Ireland fast fibre broadband and its twin, cloud computing.

9.2 Smart Cowen

Ireland's equivalent to President Barak Obama, Taoiseach Brian Cowen, published a call to arms in December 2008 with the publication of *Building Ireland's Smart Economy - A Framework for Sustainable Economic Renewal* where he said: 'The path to economic renewal starts here (GoI, 2008, Foreword)'.

Figure 54 - Building Ireland's Smart Economy.

With regard to broadband provision and schools, in 103 pages the Report contained the word 'broadband' 23 times although this included exact repetitions of earlier sentences. Our Taoiseach said this:

- The Smart Green economy will allow us develop a digital services export economy which will only require a high speed broadband network, a renewable electricity supply and our own ingenuity to succeed (p.8).
- The Schools Broadband Programme will be continued, the range of services available to schools will be expanded and the range of digital content available to schools will also be expanded (p.16).
- We will pursue the objective of equipping [75] second-level schools with 100Mb per second broadband connectivity (p.16).
- We will publish a new Knowledge Society Strategy by mid-2009 with an action plan for the use of new high speed broadband networks to further our enterprise, educational and environmental objectives.
- We will support the continued investment of some €700 million each year by the private sector in the upgrading of our broadband network via a telecoms regulatory framework which has the promotion of competition as a core objective (p.21).

- We will roll out the National Broadband Scheme, which will ensure that every part of the country has full access to broadband coverage (p.21).
- We will support investment of €70 million in international connectivity through Project Kelvin (p.21).
- We will promote Ireland as a world leader in the flexible use of the wireless spectrum including the creation of new 'ubiquitous' broadband connectivity zones (p.21).
- Broadband is a key enabling infrastructure for the knowledge-intensive services activities on which future prosperity will increasingly depend. We now have over 1 million broadband subscribers, giving penetration levels approximating to EU and OECD averages. The National Broadband Scheme will ensure 100% national coverage, with full roll out of services by 2010 to areas of the country not currently served by the market (p.96).

That's all for 'broadband'. A sceptic might note that the reference to rolling out 100Mbs broadband to 75 second-level schools is a promotion of a new primary/secondary digital divide, as much a hurt to the teachers as to the pupils in the primary sector. Now to 'schools' in *Building Ireland's Smart Economy* noting that some sentences below are repeats of sentences above already:

- We will enhance ICT use in schools, working in partnership with industry to invest in ICT equipment and connectivity (p.15).
- The Schools Broadband Programme will be continued, the range of services available to schools will be expanded and the range of digital content available to schools will also be expanded (p.16).
- We will pursue the objective of equipping [75] second-level schools with 100Mb per second broadband connectivity (p.16).
- Summer schools in science and engineering will be expanded with an emphasis on innovation and commercialisation (p.16).
- An entrepreneurial culture in schools needs to be supported and developed (p.62).
- ...fostering entrepreneurship, mathematical and science skills in schools (p.74).

- In addition, the ICT Strategy Group Report, which was published in July 2008, provides a clear direction to inform actions to further the integration of ICT into teaching and learning in our schools. While there are significant challenges in implementing some of the Report's recommendations, investment in school infrastructure will be pursued within available resources (p.76).

That's it for 'schools' in *Building the Smart Economy*. To be fair to the Taoiseach, he did point out that a new Knowledge Society Strategy to be published in 2009 would fill in the blanks on details of broadband rollout.

9.3 Next Generation Broadband

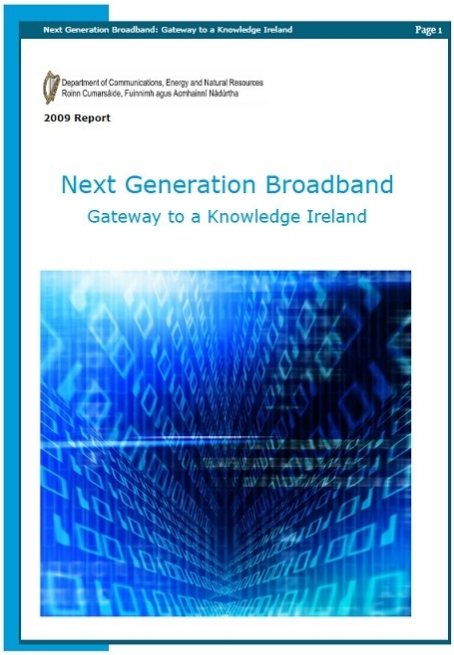

Figure 55 - NGB Report

Minister for Communications, Energy and Natural Resources, Eamon Ryan, duly published *Next Generation Broadband – Gateway to a Knowledge Ireland* (DCENa, 2009) in June 2009.

In the Foreword, the Minister recalled the Telecommunications and Internet Federation 2008 estimate that €700 million was being spent on telecoms' infrastructure but noted that the economic downturn was surely impacting on this figure and he called on the companies involved to continue investing. In other words, at the time of publication, the Minister and the Government weren't entirely sure how much was being invested in infrastructure by the private sector or how much was likely to be invested in the future.

The Minister announced four key elements to Government strategy:

- Promotion of private sector investment in Next Generation Broadband (NGB).

- An optimal regulatory framework, facilitating collaborative models of engagement among operators.
- An innovative radio spectrum policy.
- Targeted Government actions, where necessary.

The single zircon in the crown of the Government's policy at this point was surely the final rollout of the National Broadband Scheme to many areas of Ireland without any broadband coverage. The Government was contributing €79.8 million towards an overall investment programme of approximately €223 million since the NBS project qualified for EU co-funding under the European Regional Development Fund.

9.4 '3' Basic Broadband for Rural Areas

Hutchinson 3G Ltd (trading as '3') won the contract to implement and maintain the NBS in December 2008 and expected to complete broadband provision by the end of September 2010. The agreement was to provide wireless broadband connectivity in most cases, with some satellite broadband services for buildings impossible to reach by wireless. There is no specific information in *Next Generation Broadband – Gateway to a Knowledge Ireland* site about speeds and contention in the wireless service provided and indeed the Minister was closely questioned and criticised by Deputies in the Dáil on Tuesday March 2nd 2010 about slow broadband speeds generally in Ireland and about the failure in both the EU and Ireland to put in place agreed methods for analysis of claimed broadband speeds by companies on actual customer sites (Debate here).

However, on the http://www.three.ie/nbs/faqs.htm Web site details were given as follows: A total of 234,000 residential, commercial and business premises were to receive broadband connectivity across 1,028 Electoral Divisions (out of a total of 3,440 EDs) as a result of the NBS. With regard to speeds the FAQs continue:

> 'The mobile wireless broadband service (HSPA), will have a minimum download speed of 1.6mbps, a minimum upload speed of 1.2Mbps, a maximum contention

ratio of 22:1, a latency of 100 milliseconds and a 15gigabit (12 down, 3 up) inclusive monthly download allowance limit.

In a limited number of cases 3 will make available a satellite product, which may cover up to 8% of the NBS areas. The satellite product will have a minimum download speed of 1mbs, a minimum upload speed of 128kbps, a maximum contention ratio of 48:1, latency of 800 milliseconds and a 11gigabit (10 down, 1 up) inclusive monthly download allowance limit.

As part of the NBS contract 3 will deliver the following minimum speeds at launch at the edge of cell. Average speeds for customers will be higher.

Minimum download speed is 1.2Mbps while maximum download speed is 5Mbps.

Minimum upload speed is 200Kbps while maximum upload speed is 1.8Mbps.

Satellite Minimum download speed is 1Mbps.

Satellite upload speed is 128Kbps.

In July 2010 3 will deliver the following minimum speeds at the edge of cell. Average speeds for customers will be however higher.

Minimum download speed is 1.6Mbps.

Minimum upload speed is 1.2Mbps.

This is subject to contention of 22:1.

Satellite remains unchanged.

In October 2012:

Minimum download speed is 2.3Mbps while maximum download speed is 10.4Mbps. Minimum upload speed is 1.4Mbps while maximum upload speed is 4.8Mbps. Satellite remains unchanged.

The contention ratio at launch:

36: 1 contention **From 1 July 2010** - 22:1 contention ratio Satellite 48:1 contention (Link)'.

There is no question that any broadband connection is better than no broadband connection and a broadband connection that is promising to speed up over time is better than one that isn't. For a once-off charge for hardware of €49 and a monthly charge of €19.99 with the added convenience that the mobile 'dongle' is not fixed but may be moved between home, office, school or indeed anywhere within coverage - this seems to be a workable solution that many will welcome.

But is it the best solution? Does it not recall the initial schools' broadband provision of wireless and satellite which so many schools have condemned owing to speed, contention and latency and which failed many types of activity such as videoconferencing and so on? Was there another realistic solution with longer-lasting benefits that might have avoided the future requirement of migration to technology with faster speeds? Will it be overtaken in the rest of the country by cable or fibre broadband offerings? We will return to these matters shortly.

Apart from that single zircon in the crown, the Minister was announcing that 75 second-level schools would get 100Mbs broadband as a pilot for possible rollout of 100Mbps to all second-level schools at some future point. This leaves primary schools high and dry, both pupils and teachers together, for reasons as yet unexplained and hardwires a level of digital divide into the system that is impossible to ignore.

In brief, the Minister included in his announcements the following contributions to creation of the Next Generation Broadband:

- Universal access to broadband (such as discussed above).
- Broadband to schools - or maybe 'Broadband to Some Schools'.
- International connectivity - The Kelvin Interreg IV international connectivity project with a transatlantic cable coming ashore on Ireland at Portrush, County Antrim – a cross-border project connecting many towns.
- One-stop-shop - to provide service providers with flexible and open access to existing and future state owned telecoms infrastructure.
- Fibre connections in new premises – new premises in Ireland might be required to install open-access fibre connections, *where practicable*.
- Optimal regulation and innovative licensing.
- Spectrum: The use of the radio spectrum in more accessible ways (DCENa, 2009, p.17).

The entire report contains two short mentions of cloud computing, one where it is described as 'powerful computing (DCENa, 2009, p.6)' and the other where it is referred to as a 'new development in remote data storage (DCENa, 2009, p.12)'.

Schools are mentioned as getting broadband and then again in the part where 75 second level schools are getting 100Mbps. The report goes not generate a great deal of conviction in the reader that the author(s) fully comprehend the consequences and repercussions of the thinly spread devotion to Next Generation Broadband. In Section 1.1 entitled *Benefits of Next Generation Broadband* the bullet points are somewhat desultory, as when a writer is nearing the end of a long paper and is tired: Economic Development, Sustainability, Social Inclusion, Education, Public Services, R&D, Products & Services.

There is no sign that they know how to effectively use NGB in the Government itself, nor is there any energised seeking after the immense savings of combined virtualization and cloud computing across the entire Public Service sector such as in Britain with the plan to create a G-Cloud with savings in the billions of pounds and in Japan where they are building the Kasumigaseki government cloud. There is no Obama-style MLK conviction of the *I Have a Dream* to regenerate all of the country, including rural Ireland, and give all school children equal digital literacy and citizenship. Instead, it is a somewhat desultory and tired document. There is no idea to leverage the entire Government and Public Service ICT budget toward a single provider who will, in turn, bring fibre to all schools in the country however long it might take. There is no spirit of the convert but rather the lacklustre personality of the temporary hired hand. The Minister in this document is a peacock with only one or two tail feathers for show.

9.5 Knowledge Society Supports High Bandwidth

The Minister referred to the future publication of another document by his Department in July 2009 under the heading *The Knowledge Society Strategy – Technology Actions to Support the Smart Economy* (DCENb, 2009). Unlike the cloud-shy *Next Generation Broadband* document just covered, the new one is clearly written by expert technophiles so that it devotes a total of 19 detailed pages to cloud computing and virtualization among its total of 95 pages. While this study tends to look at cloud computing from decidedly narrow confines – cost savings to schools, delivery of software services to schools, minimising school hardware – the new paper takes a holistic view of cloud computing and virtualization in the sense that it sees

them as creating opportunities for research and development, jobs and profit at every turn.

Clouds run in data centres – data centres may be made to run cheaper, greener and smarter and may be cooled in new and unusual ways to save money and to allow research and to create jobs. Clouds may not only store data but also in some sense process it, deduplicate it and variously offer methods to 'add value' to the hosting data centres. It covers the showcase developments of data centres and clouds in Ireland, such as the Cork Internet eXchange - A Hyper Energy-efficient Data Centre, IBM's Dublin Cloud Laboratory, Microsoft's Dublin Cloud facility and research centre, and Eircom's Managed Services Data Centre at Clonshaugh, Dublin.

Reading this new paper is like speed-dating every new technology, innovation and problematic issue related to the island of Ireland such as the Metro Bottlenecks, Lero, CLARITY, Fibre Underutilisation, Optical Burst Packet Switching and Transport (OPST), Tier-1 Backbone Providers, Direct Access to an International IP Backbone, Intune Networks and the Exemplar Smart Network – but at the heart of it is a deep understanding of the infinite benefits to Ireland of three concepts: cloud computing, virtualization and fibre broadband connectivity across the island which it is not afraid to put in print as it goes:

> 'For all-Ireland to participate in the Smart Economy there is a need to build a low-cost, high-resilience, high-bandwidth, low-latency fibre backbone throughout the island. Such an infrastructure would allow CIX to demonstrate, in partnership with IBM and others, the capabilities of Cloud Computing and the capabilities of Data Centre consolidation using geographically dispersed regional facilities (p.39)'.

> 'It is also imperative that connectivity between Dublin and the regions is improved using existing fibre infrastructure owned by Semi-state companies – ESBT, etc. The Government should consider intervention on national connectivity at high-capacity levels (multiple wavelengths or even dark fibre) from Dublin (where the only IP backbone PoPs are) to the major urban areas outside of Dublin (Cork, Limerick, Galway) as current pricing is not competitive. ..This would also prove the concept of reducing the number of Government Data Centres, and be the first

step towards setting up an R&D centre for Data Centres and Cloud Computing, (p.45)'.

'For a modern, sustainable society to prosper fully, broadband communications must be available to the entire population in all areas (p.49)'.

'It is likely that fibre networks will ultimately be required for the best broadband (p.51)'.

This is the Minister's own Department orating but the Government seems a long way from listening.

9.6 Forfás Report

Finally in January 2010, Forfás, Ireland's National Policy Advisory Body for Enterprise and Science, published a hard-hitting review of broadband policy in Ireland with no favours accorded to 'the incumbent', Eircom, for its pricing and services generally. However, it is Forfás' contribution to the fibre broadband debate that is relevant here and to that we will immediately turn. If Forfás were also to call for fibre broadband provision across the island then this would indicate a low-level civil war between the Minister (representing the Government) and his various ICT-related Departments.

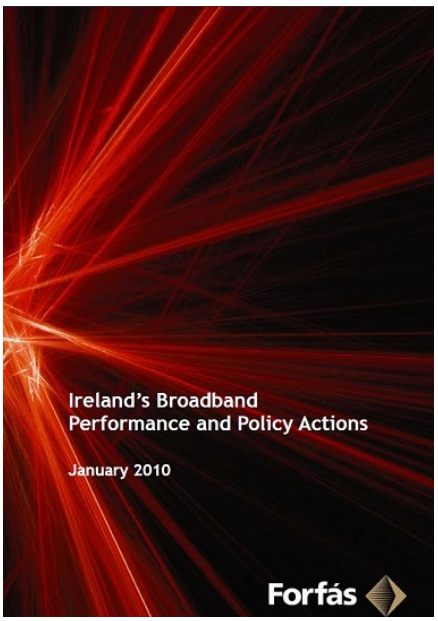

Figure 56 - Forfás Report

Forfás describes the broadband recently provided in rural areas as nothing more than 'basic broadband' and goes on to note that Ireland is lagging at least 3 to 5 years behind its European competitors in terms of rolling out infrastructure capable of high speed next generation broadband (Forfás, 2010, p.4).

Only a few points are required to be represented here from the Forfás review:

- In Ireland only 0.6 percent of total broadband connections are fibre connections. This compares to 11.3 percent of subscribers in OECD-28 countries currently accessing the internet over fibre connections, 21 percent in Sweden, 46 percent in South Korea and 51 percent in Japan. Fibre to the home connections (FTTH) are increasing rapidly in a number of central European countries including Latvia (26.7 percent of fixed broadband connections are FTTH), Estonia (20.6 percent) and Slovenia (10.5 percent). Fibre connections are also growing fast in Denmark, Norway, the Slovak Republic, Hungary and the United States (Forfás, 2010, p.4).
- Ireland remains behind leading regions in terms of upgrading the local access network to fibre and in offering very fast connection speeds over fibre and faces a significant challenge to upgrade the access network in particular to support next generation broadband. Ireland's key weakness is the lack of deployment of fibre in upgrading the existing copper network to an optical fibre network, namely fibre to the street level/cabinet (FTTC) and fibre to the home/premises (FTTH) (Forfás, 2010, p.4)'.

It goes on to quote the Communications' Regulator (ComReg) who said that we 'have barely begun to see the deployment of next generation broadband access networks' in Ireland. It expresses its 'concern' over what it calls 'slow progress' in implementing networks capable of bandwidth-intense applications and services which other countries are beginning to provide. This might tempt ICT companies to move to exploit next generation networks elsewhere, since Ireland lags so far behind. Actions taken to date by the Department of Communications, Energy and Natural Resources are, it declares, 'not sufficient to achieve a leadership position'. If either private investors or the State itself don't act, Ireland will lose competitiveness.

Finally it warns Government: 'A number of countries have determined that fibre connections are critical to developing a digital economy and are committed to strong public intervention to ensure this utility becomes widely available in a timely and cost

competitive fashion, and in some cases are investing directly in the market (Forfás, 2010, p.7)'. From July 1st 2010, Finland has declared that citizens may regard fast broadband connectivity as a universal service like the telephone or postal service, and has required all Universal Service Providers by law to ensure that every customer is in receipt of at least a 1Mbps download speed (Finnish Ministry of Communications).

Cisco produced a slideshow document for the Irish Communications' Regulator in 2008 subtitled 'Why Spectrum Matters' and in a few simple graphics told the sorry tale of the next decade and Ireland's failure to participate in it. Firstly, it showed the future demand for bandwidth:

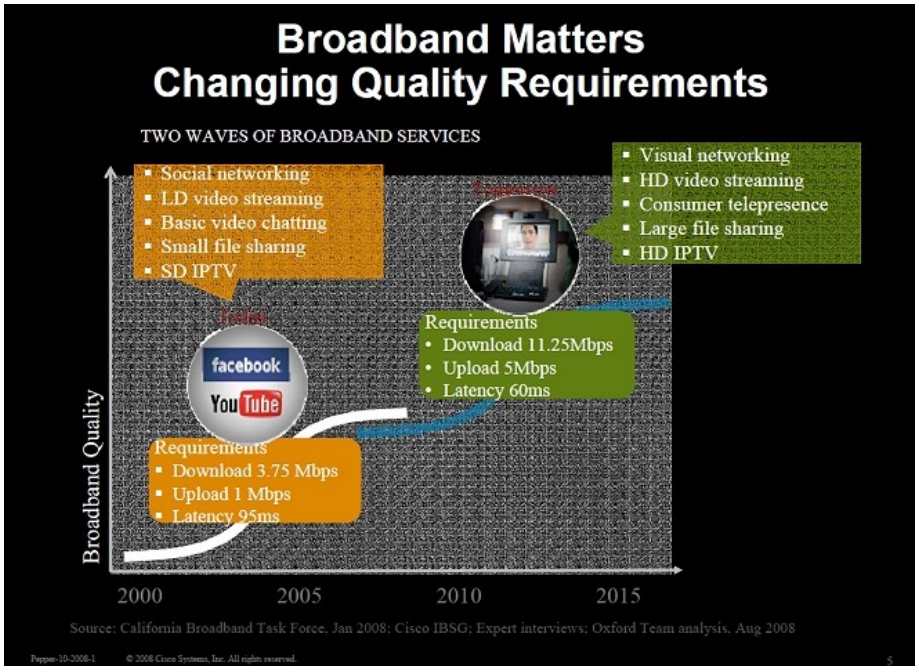

Figure 57 - Future Broadband Requirements, Cisco.

Then it showed where Ireland fitted currently in readiness for Next Generation Broadband using a widely used analysis tool the 'Broadband Quality Scores' system (BQS):

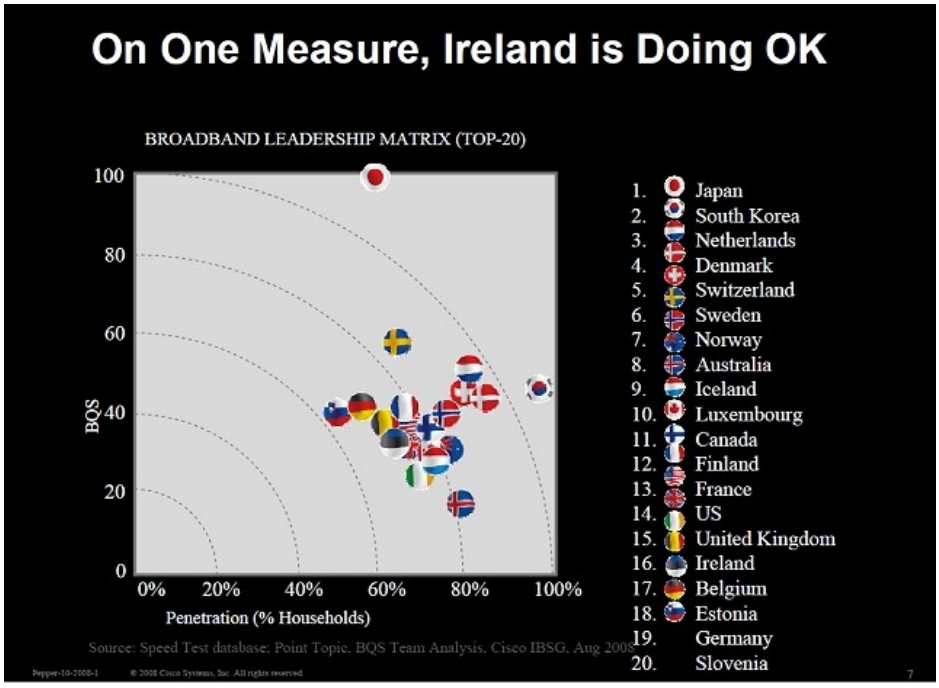

Figure 58 - Ireland Doing OK, Cisco.

And then it looked ahead a little:

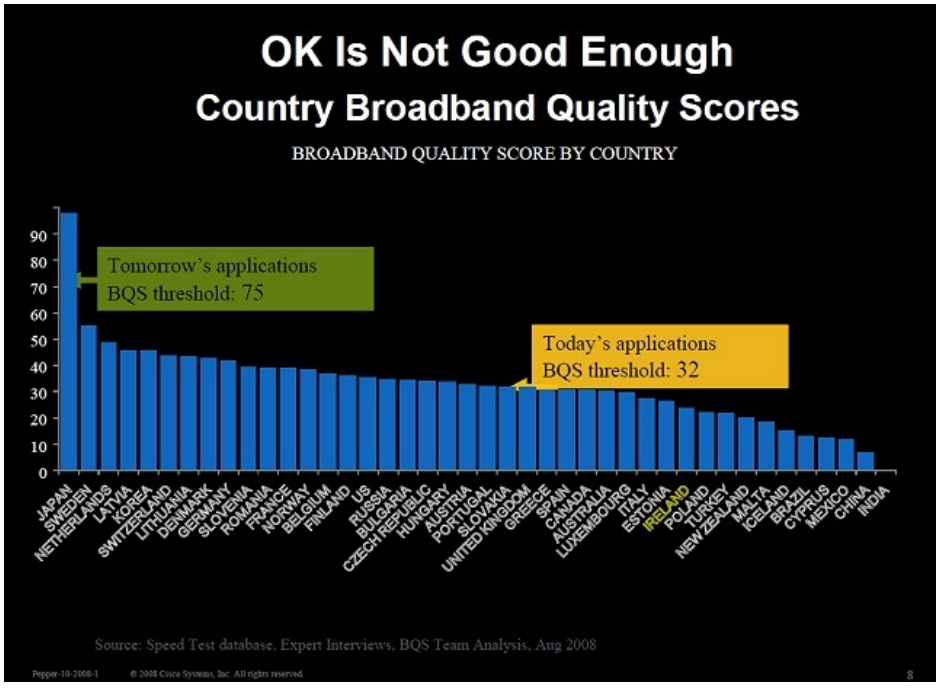

Figure 59 - OK Not Good Enough, Cisco.

This final conjunction of the views of both Forfás, of the Minister's own Department expressed so cogently in *The Knowledge Society Strategy – Technology Actions to Support the Smart Economy* and of ComReg about the importance of the twins of cloud computing and its infrastructure, fast fibre broadband connectivity, allows this study to move to its concluding arguments.

9.7 Conclusion

While the American, British and Japanese governments are showing really expert knowledge and desire for the benefits of cloud computing, virtualization and fast fibre connectivity, the Irish government hasn't wakened up to smell the clouds of coffee, busy perhaps rolling out only a most basic broadband across the country via 3. However, some governmental entities have grasped the cloudy and fibrous grail, but perhaps without the vital interest of the Cabinet.

10 A MANs Solution

10.1 Introduction

This chapter proposes that the government take a holistic view of broadband and ICT provision nationally, and leverage the entire public service ICT budget in such a way as to conclude a deal with a single giant provider to use the large areas of existing fibre across the country to launch the connection of all schools (and surrounding communities) to fast fibre broadband. To showcase Ireland's talent, it proposes the creation of the world's first E-Cloud to service all schools and colleges in Ireland and the replacement of the wholly inexpert NCTE.

10.2 A MAN for all Seasons

What is the reason for the Irish Government's lacklustre inattention to the requirements of Next Generation Broadband and to equalising the broadband experience across all of our schools and for all of our students – working citizens of the future – and teachers of the present, not forgetting the communities around those

schools who would also benefit by the provision of fibre broadband? What madness would desire Irish children in primary schools in their first 8 years of education to be sidelined from the benefits of Next Generation Broadband and Learning Powered by Technology for reasons as yet unstated and as yet unsupportable?

Can it be that the Government is afraid to spend the money, after incomprehensibly vast amounts of our money and borrowed money have been poured down the black holes of various banks as the song says – 'Will there be not a trace left behind' – when every penny spent on schools is guaranteed to bring a dividend in a workforce of the future whose backs will bear the repayments of these vast sums?

Does our prodigal Government not grasp the calculable savings brought about by virtualization and cloud computing across public services which are being implemented by governments abroad with alacrity? Does it not see the dividends likely to arise from R&D and from the satisfaction of the many foreign companies investing in Ireland when Next Generation Broadband and its siblings virtualization and cloud computing are given a real chance, backed by Government in an investment where things can only get better? The solution is right in front of the Government's nose which may currently be too deep in the Bankers' trough to see clearly.

The solution lies in extension of the MANs and related fibre networks to the schools. The Metropolitan Area Networks already cover a great part of the island:

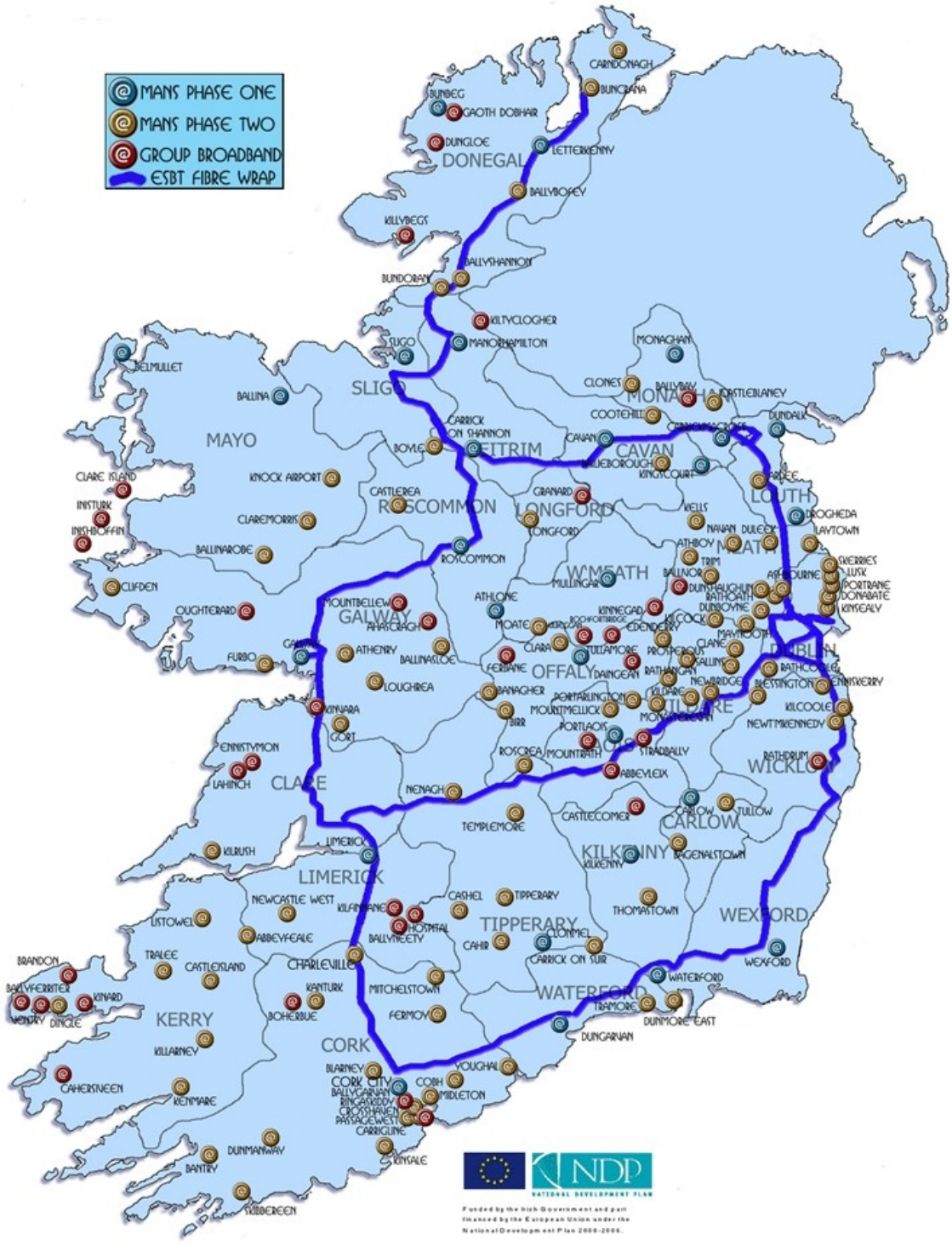

Figure 60 - MANs Map Phases

This map shows the phases of development of the MANs which are now managed by e|net Ltd (www.enet.ie) as a neutral carrier – any telecom or ISP can use the MANs. The next map shows the e|net view of the MANs now completed:

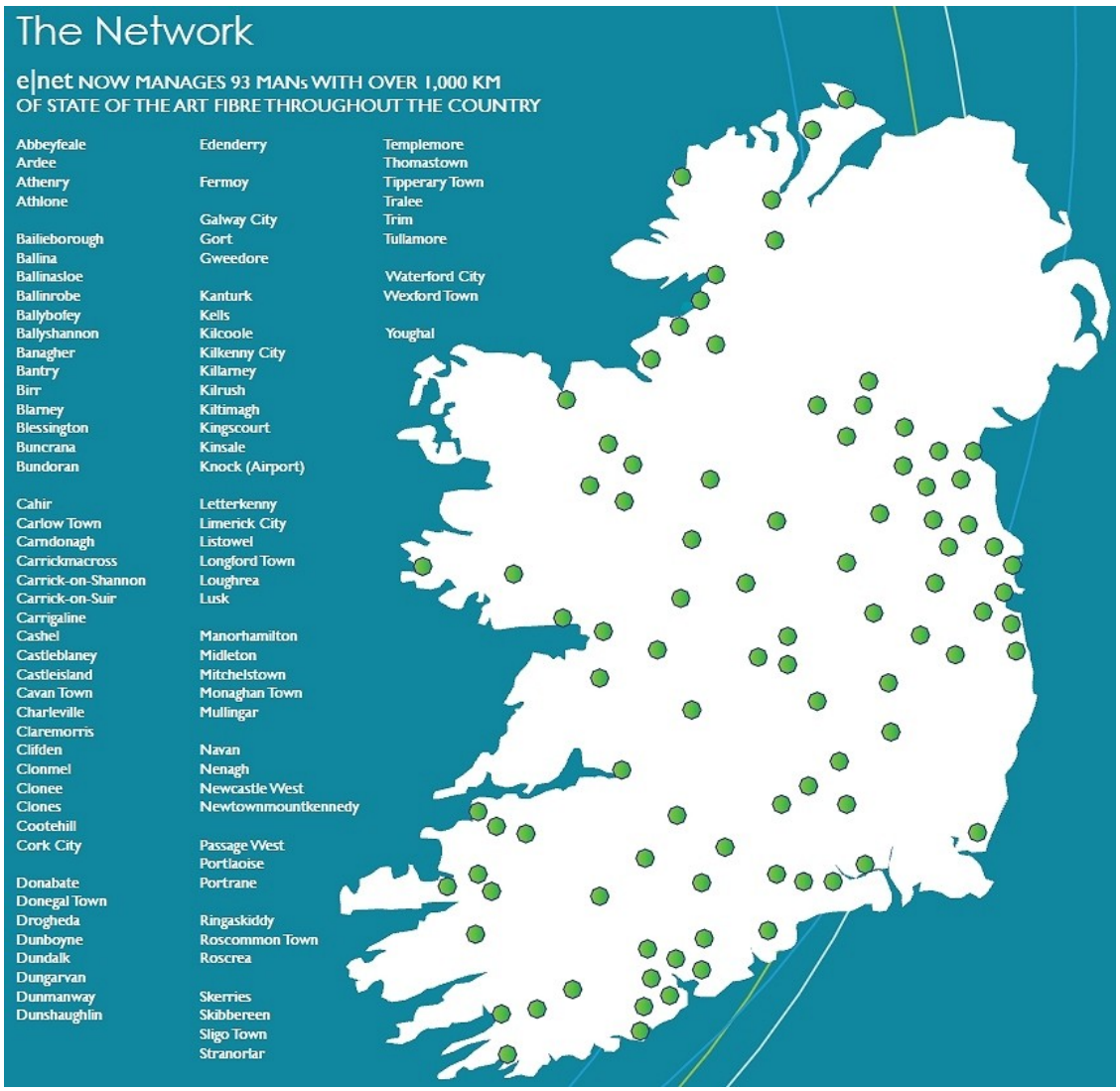

Figure 61 - Network Map from the e|net brochure.

e|net has already been contracted to connect 24 of the 75 lucky-lotto secondary schools to the 100Mbps network – why not just give e|net the task of connecting all the schools, in a duopoly deal with whoever can do it best, Eircom or whoever? Leverage the sizeable Government and Public Service and Military and Police ICT budget against such a deal to entice the entrepreneurial.

Apart from this massive fibre backbone, there is the HEAnet fibre backbone, though HEAnet leases 'dark fibre' (unused, unlit fibre) for its own network – but it already connects a number of third level institutions in Ireland and across the world and even crosses the border and enters the dark fibre territory of Northern Ireland:

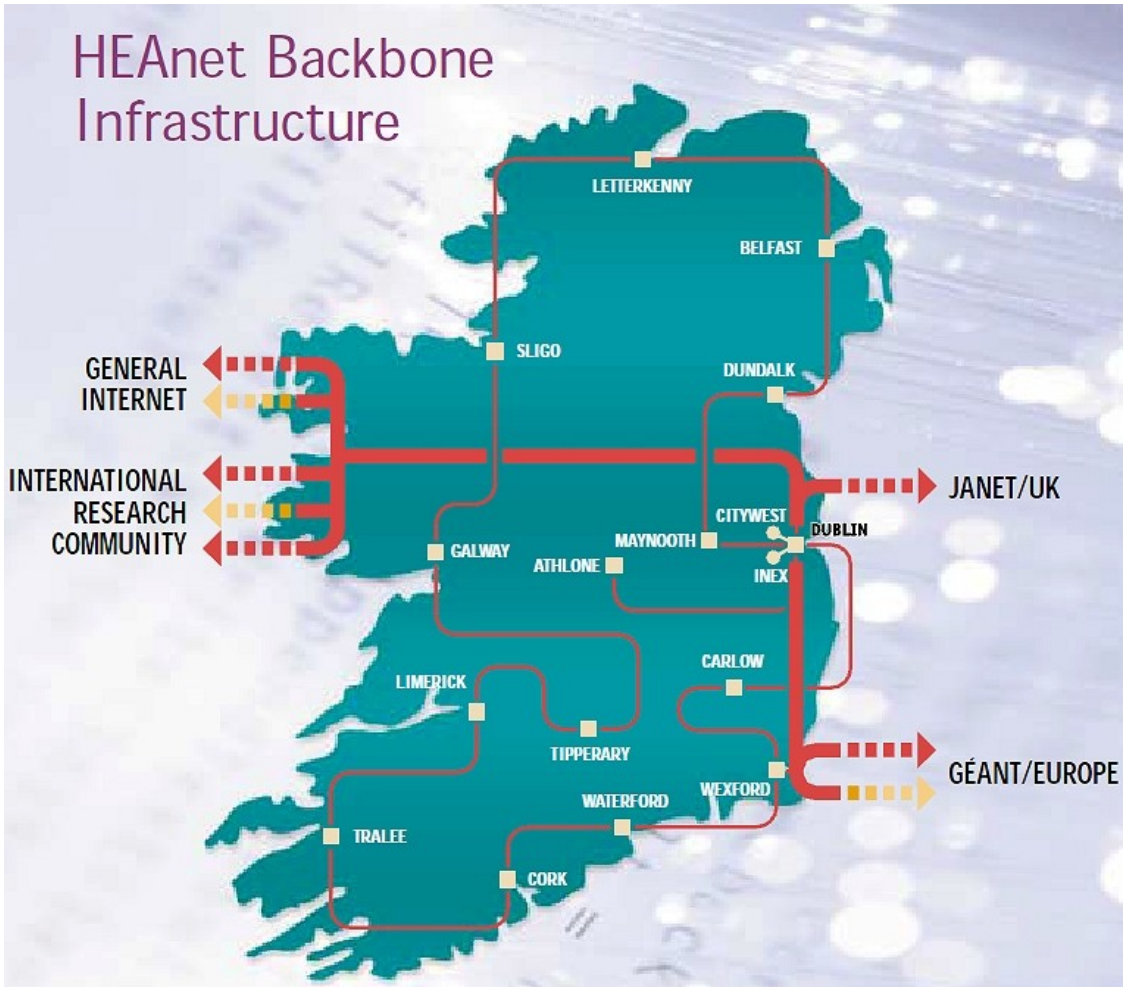

Figure 62 - HEAnet Backbone Infrastructure.

Apart from these two fibre networks already in place, there is a lot more fibre lying around underused such as indicated in the following maps of publicly-owned infrastructure – there is, for instance, the CIE Fibre map:

Figure 63 - CIE Fibre Map

Seeing is believing – there is also the ESB fibre map:

Figure 64 - ESB Fibre Map

There are other maps: the Waterways of Ireland Navigational Network Possible Broadband Provision Map, the National Roads Authority Duct Provision Map and even the Ducting Adjacent to the Bord Gáis Infrastructure Map. It's not as if the Government is being asked to start from scratch – it would be starting near the finishing line of Fibre Broadband for All Schools.

10.3 The E-Cloud

A small country of 40 shades of green and thousands of shades of rain should at last embrace the Cloud which desires to rain down benefits on us all but particularly on schools in ending the nightmare for principals and teachers alike of hardware and software obstacles, whether of purchase, licensing, repair or technical support. Create an E-Cloud (Education Cloud) to cover all schools in Ireland. If we cannot afford new technology for schools, then let us follow the example of Pike County where the Cloud provision allowed old hardware to bloom again indefinitely.

Centralize the provision of everything a teacher would want on a screen – add value by providing what teachers didn't even imagine they could have – experts to cover class matters they are not too sure of via TeachTube from the Cloud; language classes from sister schools in Europe streaming live across the Web; virtual tours of places the students will really visit later; video and 3-D explanations of sport and health and bodily matters; the class is not really getting First Confession or First Communion – get the Pope on the screen to explain all about it. Give STEM (science, technology, engineering, math) matters a real chance from the Cloud – catch the interest of students young and you have them for life. Give students of all ages a safe space in which to meet their peers – not FaceBook but SkoolBook. Give all teachers a repository of support and expert help a click away. Let the classrooms catch up with the world outside the classroom in terms of touch screens and mobile devices all seamlessly connecting to the safe E-Cloud. At last lead from the front for a change and embrace the Cloud sailing merrily across the Fibrous skies.

In a Republic, do away with second-classes of digital citizenship – give all schools an equal digital literacy, not just higher classes. Treat all children of the nation equally.

Our third-level institutions, already greatly favoured by provision of HEAnet, should give something back to lower schools – come together to create the E-Cloud resting digitally in the HEAnet backbone and university data centres – use the series of relationships already existing with multinational companies to partner in the design, creation and provision of Ireland's E-Cloud. Those who are already drawing a salary need not always ask to be paid extra for giving something back.

Let the NCTE be replaced by a truly expert and unpaid open-source-motivated E-Cloud committee split between technophiles who know what they are about to look after the E-Cloud infrastructure and the pedagogues who should busy themselves with what they are trained to know about – the teaching content that should be in the Cloud.

Stop the endless circularities in Irish education around ICT of creating Advisory Committees to tell other Committees how to do what they don't know how to do – go directly to those who do know how to do it and get them to do it straightaway without delay supplemented by two layers of Committee deliberations and financial waste. Let those who don't know stand aside and stop blocking the corridors to progress.

10.4 Conclusion

This chapter pointed out that Ireland would be starting near the finishing line if it decided to connect all schools to fast fibre broadband, since there is a great deal of fibre around the island already. It would showcase Ireland's real smart economy to create an E-Cloud to provide for all schools and colleges to create real digital citizenship for all the nation's children.

11 Conclusion

11.1 Introduction

Ireland cannot be proud of a decade of mismanagement of ICT in schools to the point where tens of thousands of obsolescing computers obstruct rather than service the needs of students and a great majority of teachers are dissatisfied with the very lifeblood of Internet experience and enjoyment – fast broadband connectivity. Schools are lagging behind the exciting advances in mobile connectivity and opportunities for learning which are multiplying in the world outside to the detriment both of student/teacher relationships and of the opportunities in schools to instil a more formal and coherent love of scientific and technological prowess in young minds, workers of the future.

0.6% of Irish homes and businesses, and 0.0% of schools, have fast fibre broadband Internet connections while we have a number of large and underutilised fibre networks spanning our relatively small land area. Scarce monies should not be wasted on provision of second-rate broadband connectivity for schools which will require revisiting later with more money to enable migration to faster speeds. Ireland's claim to want a share in the world's Smart Economy and Knowledge Society must be expressed in a commitment to develop fast fibre connections to all schools, avoiding second-class digital literacy and citizenship and a digital divide, and utilising them via an E-Cloud (education cloud). Our school learners now are our entrepreneurs and employers, workers, scientists, researchers and discoverers of the future on whom we will depend in our senior years.

This chapter reviews the dissertation and the research carried out in its production. The research is critically evaluated and recommendations are made.

Future research areas are also discussed in this chapter. As the field is still very immature the scope for future research is very broad indeed.

11.2 Contribution to the Body of Knowledge

This study has delved into the history of ICT provision in Ireland and uncovered a mismanagement of serious proportions:

- Failure to centrally design and control spending on school ICT from the beginning to enable standardisation of ICT and networks and their maintenance;
- Appointment of unskilled, unqualified 'ICT Coordinators' to implement ICT in schools who were in fact nothing more than seconded teachers;
- NCTE offering annual reports that were too optimistic until the OECD broached the truth about teacher dissatisfaction and major ICT and broadband problems.
- Highlighting central flaws in Schools Network connectivity by use of the mess of ISPs.
- Suggestion of Cloud Computing and Virtualization benefits for schools and the creation of an E-Cloud (education cloud) for schools;
- Suggestion of providing fibre broadband to all schools equally using the MANs and associated fibre networks across Ireland, if necessary leveraging Government and public sector IT contracts to entice one or two giant providers to implement the fibre connections;
- Call for all schoolchildren (and teachers) to be treated equally in terms of digital literacy and citizenship opportunities and avoidance of second-classes of citizenship.

11.3 Research evaluation

Few sectors in society can avoid fundamental shifts in computing but schools in particular cannot afford to do so. The advent of a trinity of factors – virtualization, cloud computing and fast fibre broadband – must be allowed to impact all of our schools with all of their associated benefits for students and teachers alike who form a community of learning, quite apart from their considerable cost savings.

Through a review of the literature and commissioned reports by many Government and International agencies, the aims of this study have been achieved:

- Research and explain Cloud Computing and its implementation in other educational settings abroad, such as in Pike County, Marist College and University of North Carolina.
- Research and explain Government implementations of Cloud Computing such as in Britain (the G-Cloud) and Japan (the Kasumigaseki Cloud).
- Research and explain Virtualization and its cost benefits.
- Evaluate previous ICT policy affecting schools primarily by close reading and evaluation of reports by the body charged with implementing ICT in Irish schools for over a decade, the National Centre for Technology in Education and associated reports of Government Departments.
- This evaluation discovered many areas where there was a mismatch between the reported outcomes and the actual outcomes in schools, in particular with regard to technical support across the country which was largely mismanaged from the beginning.
- Personnel placed in senior positions overseeing ICT matters in schools had no training or qualifications in the fields concerned and were unable to steer schools away from the mess that occurred when ICT hardware was purchased in a national free-for-all and then not properly maintained.
- Reports continued to paint a rosy picture to the Government until suddenly in 2007 the OECD published material where teachers were in a great majority highly critical of ICT.
- Purchased broadband speeds were in many cases entirely useless, obstructing classroom teaching greatly; 47% of Irish schools reliant on inadequate satellite connections.
- Other reports outlining strategies to solve the problems themselves contained major flaws which dog the country to this day, such as the mess of ISPs supposedly providing connectivity to the Schools Network on HEAnet.
- Show major errors in NCTE oversight of policy, culminating in the criticism of its plan to purchase 4,000 servers to enable ‘technical support’.

- Research President Obama's plan to transform American schools by smart use of technology, among other factors.
- Examine Irish Government policy toward the Knowledge Economy and Smart Economy and suggest solutions to issues the Government can't seem to master, such as provision of fibre broadband to all schools (and surrounding communities) by using the MANs and leveraging Government contracts, and the creation of an E-Cloud (education cloud) by a combination of our third level institutions and partner IT business interests.

11.4 Recommendations

This study's key recommendations are summarised below:

- 4,000 schools cannot maintain tens of thousands of individual hardware units themselves and cannot afford technical support contracts – move the computing burden to a purpose-built E-Cloud (utilising virtualisation) which centralises all applications and their associated needs such as security, licensing, updating, anti-virus and SPAM, etc.
- Schools cannot get value from either the Schools Network on HEAnet or from the Internet generally after over a decade of spending owing to slow ISP connections with major contention issues, particularly in satellite provision where some 47% of schools are reliant on a service that cannot deliver – deliver fibre broadband connectivity to all schools in Ireland utilising the MANs and associated fibre networks publicly owned; if necessary, leverage Government contracts as one to entice one or more giant providers to take on the task of connecting the schools.
- Keep a sharp division in future between teachers who are trained to teach and technology and software experts who are trained to design and maintain ICT infrastructure; teachers should teach and IT professionals should do the networking and hardware (which should become transparent to teachers).
- Take central control of all school ICT purchases using a single model for all schools hardware and networks to enable easier ICT set-up and maintenance.

- Let all children of the nation be served equally in ICT provision so that each has full digital literacy and citizenship, avoiding occasions that might encourage a digital divide.
- Replace the NCTE with a voluntary body to oversee creation of the E-Cloud (technophiles and experts only) and to oversee the E-Cloud content (pedagogues only).

11.5 Future Research

The following areas suggest themselves as fruitful for research:

- Technical specifications of and pedagogic content for the E-Cloud for schools.
- Cheapest methods of connecting the MANs to all schools by means of fibre.
- The school of the future – what does it look like based on international reports from American, Japan and Scandinavia?
- A complete hardware/software census of all schools since no-one is too sure at this point how many computers are out there and what ages they are.
- Finland and Estonia have made it a 'right' for every citizen to have broadband – is this right?
- Model a joint Scandinavian and Scottish and Irish plan to deliver fibre broadband to isolated rural schools, examining EU funding opportunities for same.
- Is it possible to run a school entirely without computer 'boxes' – can it run on touch screens and input devices alone using the Cloud and any extant technologies?

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